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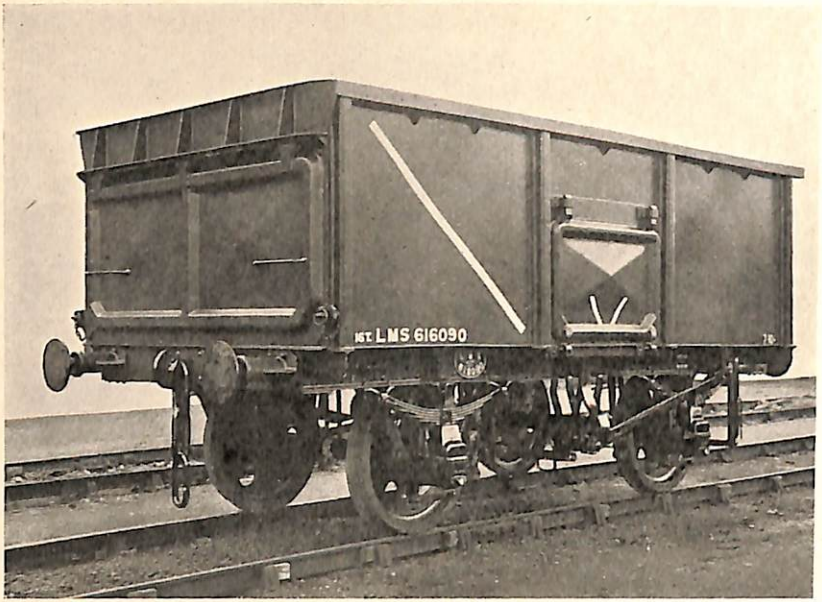

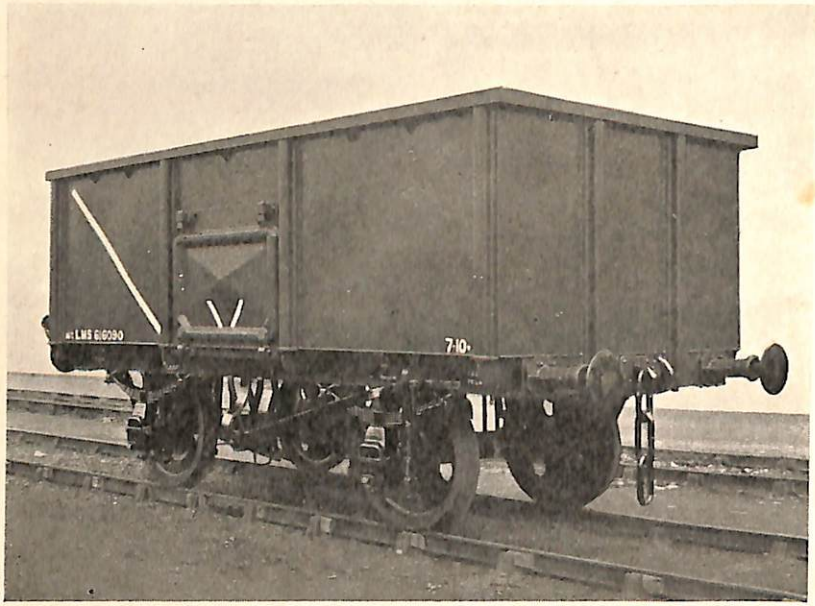

Frontispiece

16-TON ALL-STEEL MINERAL WAGON (1947)

RAILWAY WAGON AND TANK

CONSTRUCTION AND REPAIR

BY

F. OGDEN

LONDON
SIR ISAAC PITMAN & SONS, LTD.
1948

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FOREWORD

In this era, when we see on every hand evidence of the progress that has been made in industry by use of modern machinery and mechanical aids, it is hard to believe that so important a link in our transport system as the Railway Wagon Building and Repairing Trade, apart from the adoption of a few modern tools, is still operating tools and machinery up to sixty years of age.

One of the chief reasons why this trade has not been organized and developed efficiently, in my opinion, is that, although the rolling stock fleet has been expanded to meet the requirements of the industry, insufficient attention has been paid to technical training for those employed in the trade. As a result, instead of a steady flow of efficient modern-minded labour into the industry, the whole position has been left to the initiative of the individual employer, who is not always practical.

The author of this book is a practical builder and repairer, who has spent a lifetime in the industry. He now places the whole of his knowledge and experience at the command of those who have a practical interest in the trade. Our thanks are due to Mr. Ogden for the manner in which he introduces his subject and develops it to cover the various classes of rolling stock. There is a great mass of detail carefully set out, in a manner easy to follow, dealing with wagon and tank car construction, together with explanations of how and why the details are laid down.

In conclusion, I commend this book to all who are engaged in the Wagon Trade, building or repairing. I hope to see it adopted by our Education Authorities as conveying to all the high degree of training and skill required to become efficient craftsmen worthy to serve in this important industry.

C. T. SAGE

National Organizer,
Vehicle Building Section,
Amalgamated Engineering Union.

INTRODUCTION

SINCE the early days of civilization, carts, wains, and wagons have formed the basis of transportation. The first carts used were road carts, and from 1650 onwards they were used for carrying coal from the mines. Unfortunately these road carts, owing to the weight they carried and the poor condition of the road surface, caused deep ruts to appear in the road, which had to be filled periodically with wood and stone. It was these periodic repairs which eventually led to the idea of a wooden track.

As the idea of a wooden track developed, the construction of carts was improved to carry heavier loads. Eventually the limitations of balance of heavier loads on two wheels, and the desire to carry still larger loads, led to the construction of four-wheeled wagons. Each improvement to the road wagon was naturally with a view to carrying heavier loads, and these increases in the tare weight of the wagon and load necessitated further strengthenings of the track, until by gradual stages the railed track was developed.

Before the advent of the locomotive, there were two main sources of motive power used on this railed track. Firstly, horses were used, but this was naturally very slow. Accordingly various works and mines, where a rail track could be laid on sloping ground, conceived the idea of using the force of gravity. A double track was laid on the sloping ground and six or eight loaded wagons running down the track were used to pull an equal number of empty wagons, attached by rope, up the other track.

The first attempts at the invention of steam locomotives were about 1780, but it was not until 1824 that success was achieved, when George Stephenson built an engine which proved to be a successful motive-power unit. The main factor contributing to the success of this engine lay in the leading of waste exhaust steam, by pipes, into the chimney, where the action of the steam exhaust expending itself created a forced draught to the engine fire-box, thus generating more heat and, of course, a greatly-increased steam pressure. Previous to this invention the forced draught had been attempted by the use of hand-operated bellows, but without much success.

The Stephenson engine was a proved success, and from that date the railway organization began to grow. It must be recognized, however, that the subsequent improvements to the railed

tracks and locomotives are only accessories, furthering the utility of the railway wagons. The railway wagon is the indispensable link between all forms of transport, and functions efficiently through the skill and energy of the railway wagon builders and repairers, who thus form an industry of primary importance to the well-being of the nation.

The construction and repairing of railway wagons and tanks is a very complex subject, and it is the aim of the author to give, in this book, both theoretical and practical instructions for carrying out the various operations involved. This plan will cover all operations from the simplest to the most complex and will, at the same time, include an outline of the essentials required in the training of apprentices.

I desire to express my appreciation and thanks to my wife, Mrs. G. L. Ogden, for the assistance given in the preparation of this book; and also to my colleagues, Messrs. John Oxley, Frank Ellis, and G. T. Billington, for their work of verification.

I am indebted to Messrs. Taylor Bros. & Co., Ltd., Manchester, for details of railway wheel construction.

FRANCIS OGDEN

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CHAPTER I

TOOLS

SHARPENING chisels, plane-irons, and handsaws—Useful hand-tools for the wagon builder and repairer—Workshop tools (description and use)

SHARPENING CHISELS, PLANE-IRONS, AND HANDSAWS

IT is essential for efficient wood-working to use sharp tools. The points to bear in mind when sharpening flat tools such as chisels and plane-irons are—

1. Sharpen at the correct angle.
2. Keep the sharpening line at that angle only.
3. Clean off the burred edge carefully.

Polishing the Tool. Before beginning to sharpen the tool, carefully polish the surface with knife powder and a piece of cork; a little paraffin may be used in addition if there is any accumulation of dried oil or rust on the surface. The object of this polishing is to reduce the friction of the tool on the wood and to leave the cutting edge free from tiny indentations.

The Setting Edge. As tools are rarely ground at exactly the same angle, it is not easy to give directions for the setting angle in terms of degrees. For wood-handled chisels up to 1 in. wide, the approximate setting angle is 15 degrees; over 1 in. wide, 15 to 25 degrees. For all-steel chisels the approximate setting angle is 20 degrees. An experienced wood-worker can tell by the cling of the tool to the stone whether he is sharpening at the correct angle or not, but this needs considerable practice. The best way for the less-experienced worker is to place the tool on the stone so that the bevel lies quite flat, then raise the other end of the tool so that the angle made to the face of the stone is very slightly increased. If there is any doubt as to the angle, err on the side of making it too fine. The tool should never be allowed to scratch the surface of the stone.

The Sharpening Operations. Having obtained the correct angle, push the tool backward and forward the full length of the stone with firm regular motion. If the tool is wide, as with plane-irons, a diagonal direction should be given to its path on the stone. A frequent cause of error in sharpening is the use of fingers and elbows to provide force for moving the tool. As far as possible this propelling force should come from the shoulders, as otherwise it

is clear that the angle of sharpening will vary slightly and a rounded edge will be obtained. The backward-and-forward motion should be maintained until a burred edge appears on the flat side of the tool. This cannot as a rule be seen easily, but it can be felt at once by passing the finger along the back of the tool. The ideal condition is to complete the sharpening without removing the tool from the stone, but this needs much practice.

Removing of the Wire Edge. It is now necessary to remove the burred or wire edge. The tool is held with its bevel side uppermost firmly and perfectly flat on the stone and drawn backward and forward with a shearing motion, the pressure being applied on the backward stroke. In this way the wire edge is crumpled up and ground away, leaving a clean cutting edge.

Stropping. The tool should now be stropped to give a final edge. A safe and efficient strop can be made by tacking a piece of fairly wide buff leather on a batten, taking care of course that the tacks are inserted over the ends of the batten so that they cannot come into contact with the tool. The leather should be dressed with Russian tallow. The tool is given two strokes on its bevel side on the strop and some half-dozen strokes on the flat side. In the latter case the tool should be smacked down firmly but squarely on the strop.

Care of the Oilstone. Respect your oilstone. Do not let it get dusty or corroded with oil. After using, wipe the stone clear and occasionally wet a rag with paraffin and rub the surface of the stone so as to clear congealed oil from the microscopic holes which are present in all oilstones and which take a definite part in the sharpening operation. When the stone wears out of true, make a dresser by gluing a piece of emery cloth on each side of a piece of smooth board—coarse grade on one side and medium grade on the other. Scour the stone with this dresser, keeping it quite flat, and test the surface of the stone with a try square. A final surface may be given by sprinkling a little emery flour on the stone and rubbing it with a piece of cork or soft wood.

Setting and Sharpening Handsaws. Firstly, clean the saw and polish the blade; if the handle grip is loose tighten the screws or rivets. Look down the blade and see if there are any indentations; if there are, have the blade attended to by a skilled saw-setter. If the saw blade is straight fit it into wood clamps, leaving the toothed edge protruding approximately $1\frac{1}{4}$ in., and taking care that the blade is gripped tightly by the wood clamps.

Levelling Teeth. Place a flat file of fine cut squarely on the teeth at the handle end, and push the file in one continuous movement

to the tip of the saw, with a light pressure. Take the file off the teeth and examine all the teeth one by one; if the file has rubbed each one the saw is termed level. If the saw blade is very hollow or uneven it is best to send the saw to a saw-setter.

Setting Teeth. Saw teeth are set with sufficient clearance to allow the thickness of the blade to be worked freely when cutting wood, and it is best to use a saw set with a lever and plunger which fits over each tooth and is so constructed that the teeth can be set at various angles. It is essential that each tooth has the same set, for if the teeth are at various angles or pitch the saw will not cut true. Having set the teeth, lightly rub a flat file over them, in one continuous movement, to the tip of the saw.

Filing of Teeth. It is important that the size of file should not be too big or too small, since either will spoil the saw. Saw teeth are of various sizes and the size of the teeth is generally the size of file required. Use a triangular file of smooth cut which fills in perfectly the space between two teeth. Having obtained the correct file, grip the file handle with one hand and the end of the file with the thumb and finger of the other hand and place in the first vee opening at the handle end. The file should be tipped up slightly, that is, the file end should be slightly higher than the handle; it should also be at a slight bevel, that is to say the handle of the file should be nearer to the handle of the saw than the point of the file.

Using the File. Having adopted a position, usually standing, use light pressure and push the file away from you. When the file has travelled its length, lift the file out of the groove and repeat. Under no circumstances must a file be pulled back in the groove, as this would destroy the sharp burred edge. Each groove must be filed the same number of times, at the same pressure, and the file must be held tightly and at the same pitch both upward and crossways. It is very important before filing to look which way the teeth have been bevelled previously and to file the same way, missing alternate grooves. An example is as follows.

If a saw has fifty teeth and grooves, and the first groove nearest the handle is filed, miss the next one and file the third groove, miss the next and file the fifth, and so on until the end of the blade is reached. The saw is now turned round and the same procedure is followed. In the case of the example taken, filing would be Nos. 2, 4, 6, 8, 10 grooves, starting from the handle end.

Saw teeth should be leaning slightly towards the end of blade, but it must be remembered if they are set too acutely the result is a very rough cut and uneven stroke.

Points to Note. 1. Do not pull the file towards you in the groove or vee—lift it clear of the teeth.

2. Always file at the same angles; slightly upward, slightly crosswise, and twisted slightly towards the saw handle.

3. Always obtain the right size of file.

4. File alternate grooves from the saw handle end, then turn the saw round and repeat.

5. Be careful of the angle when setting.

6. When levelling the teeth, use the file lightly.

Only practice will teach how to set tools perfectly, but a little thought and the methodical application of the above principles will serve to smooth away many of the difficulties which trouble not only the beginner, but also many workers who have had considerable experience in their craft.

USEFUL HAND-TOOLS FOR THE WAGON BUILDER AND REPAIRER

No.	Tool	Size
1	Handsaw	8 teeth to 1 in. for cutting oak
1	Handsaw	6 teeth to 1 in. for cutting deal
1	Hand jack plane	2¼ in. knife medium set for oak or deal
1	Hand smooth plane	2¼ in. knife medium set for oak or deal
1	Hand smooth plane	1¾ in. knife medium set for oak or deal
1	Hand rebate plane	1¼ in. knife medium set for oak or deal
1	Drawknife	
1	Spokeshave	Screw-adjusted blade
1	Firmer chisel	2 in. blade
1	Firmer chisel	1¾ in. blade
1	Bevelled-edge chisel	1½ in. blade
1	Bevelled-edge chisel	1 in. blade
1	Gouge	1½ in. bevelled inside
1	Gouge	⅞ in. bevelled outside
1	All-steel mortise chisel	2 in. blade
1	All-steel mortise chisel	1¾ in. blade
1	All-steel mortise chisel	1½ in. blade
1	Ratchet hand-brace	6 in. sweep crocodile jaws
1	Plain hand-brace	5 in. sweep crocodile jaws
1	Plain hand-brace	8 in. sweep thumb-screw fasteners
	Ridgeway Wagon-boring Bits	
1	Boring-bit lengthener	approx. 1 ft 6 in., or 2 ft
1	Centre bit	2 in. dia.
1	Centre bit	1½ in. dia.
1	Twist-shank bit	1⅜ in. dia., 12 in. twist with 2 ft shank
1	Twist-shank bit	1¼ in. dia., 10 in. twist, ordinary shank
1	Twist-shank bit	1 in. dia., 10 in. twist, ordinary shank
1	Twist-shank bit	⅞ in. dia., 10 in. twist, ordinary shank
1	Twist-shank bit	¾ in. dia., 12 in. twist, ordinary shank
2	Twist-shank bit	⅝ in. dia., 12 in. twist, ordinary shank
1	Twist-shank bit	¾ in. dia., 6 in. twist, ordinary shank
2	Twist-shank bit	⅝ in. dia., 6 in. twist, ordinary shank
2	Twist-shank bit	½ in. dia., 6 in. twist, ordinary shank

No.	Tool	Size
1	Twist-shank bit	$\frac{3}{8}$ in. dia., 6 in. twist, ordinary shank
1	Quill bit	$\frac{1}{4}$ in.
1	Rose-head countersink bit	$\frac{3}{4}$ in.
1	Turn-screw bit	$\frac{5}{8}$ in.
1	Square	12 in. blade
1	Square	6 in. blade
1	Square with adjustable blade	
1	Rough and smooth oilstone	
1	Finger oilstone	
1	Spirit-level	15 in. long
	ROUGH TOOLS	
1	Sledge-hammer, double face	7 lb
1	Hand hammer, double face	3 lb
1	Hand hammer, ball and flat	$1\frac{1}{2}$ lb
1	Hand lever-bar, H.T. steel	3 ft 6 in. long, $\frac{7}{8}$ in. dia.
1	Steel spanner, double end	3 ft 6 in., $1\frac{1}{8}$ in., and 1 in.
1	Steel spanner, double end	2 ft 6 in., 1 in., and $\frac{7}{8}$ in.
1	Steel spanner, double end	2 ft 0 in., $\frac{7}{8}$ in., and $\frac{3}{4}$ in.
1	Steel spanner, double end	2 ft 0 in., $\frac{3}{4}$ in., and $\frac{5}{8}$ in.
2	Steel spanner, double end	1 ft 3 in., $\frac{5}{8}$ in., and $\frac{1}{2}$ in.
1	Steel spanner, double end	6 in., $\frac{3}{8}$ in., and $\frac{1}{4}$ in.
1	Set drift	$\frac{3}{4}$ in.
1	Set drift	$\frac{5}{8}$ in.
1	Set drift	$\frac{1}{2}$ in.
1	Hand drift	Stem length 13 in., $\frac{13}{16}$ in. dia.
1	Hand drift	Stem length 13 in., $\frac{11}{16}$ in. dia.
1	Hand drift	Stem length 9 in., $\frac{11}{16}$ in. dia.
1	Hand drift	Stem length 9 in., $\frac{9}{16}$ in. dia.
1	Hand drift	Stem length 9 in., $\frac{7}{16}$ in. dia.
1	Cold set chisel	$1\frac{1}{2}$ in. blade
3	Cold chisel	Length 8 in., $\frac{7}{8}$ in. dia.
	MISCELLANEOUS TOOLS	
1	Tape steel rule	
1	Pocket rule	
1	Steel marking-out scriber	
2	Bradawl	$\frac{3}{16}$ in. and $\frac{1}{8}$ in.
1	Oil-can	
1	Centre-punch	
2	Saw file	
1	Handsaw set	
1	Cotter punch	$\frac{3}{32}$ in. dia.
1	Cotter punch	$\frac{5}{32}$ in. dia.
1	Cotter punch	$\frac{3}{8}$ in. dia.
1	Cotter punch	1 in. wide, $\frac{5}{16}$ in. thick
	Supply of pencils	
1	Tool-chest to contain the tools enumerated. (As these are the minimum tools required, the capacity of tool-chest should be sufficient to hold additional tools.)	

WORKSHOP TOOLS (DESCRIPTION AND USE)

Hand Tools

1. Buffer-spring Pull (Fig. 1)

Threaded through the head-stock and secured to the buffer-spring buckle.

To increase or decrease compression of laminated buffer-spring.

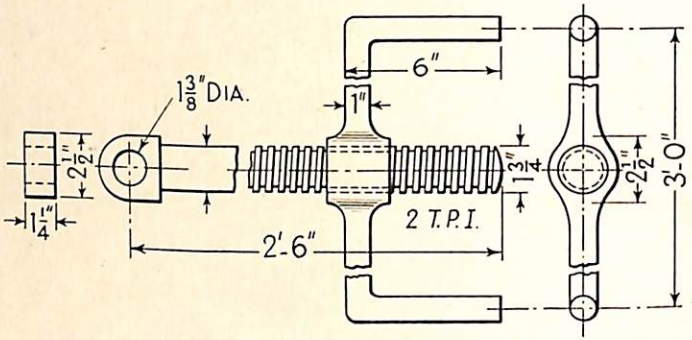


Fig. 1. Buffer-spring Pull

2. Draw-bar Hook-pull (Fig. 2)

The loop fixed on the hook and with the legs in line with the loop. The pressure between hook and head-stock impresses the buffer-spring.

To compress the buffer-spring, thus enabling a packing to be placed between the rear check-blocks and the buffer-spring and so releasing the compression of buffer-spring from the draw-bar pin. Can also be used for the fitting of draw-gear.

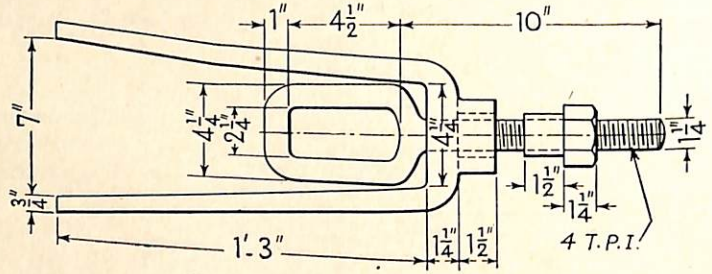


Fig. 2. Draw-bar Hook-pull

3. Brake-lever Setting-cramp (Fig. 3)

The two legs fit on the face of the brake-lever, the clip and peg fit the back of the lever, and the tightening of the screw bends the lever.

To renew the inward spring of the brake-lever.

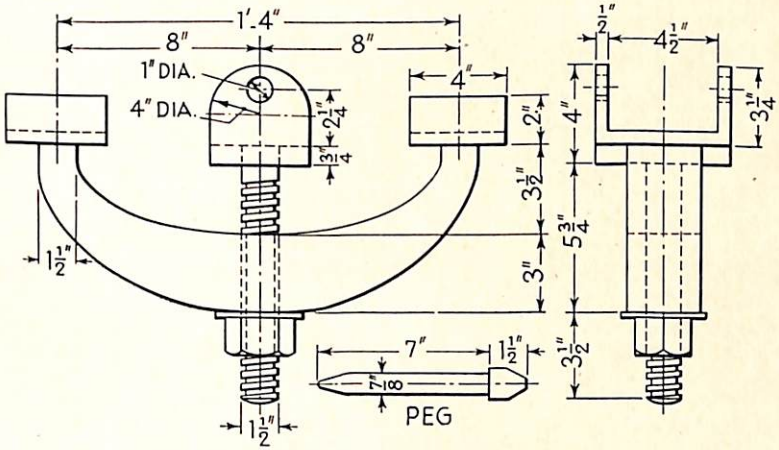


Fig. 3. Brake-lever Setting-cramp

4. Buffer-spring Cramp (Fig. 4)

The loop is secured to the buffer-guide where the tightening action of the screw compresses the buffer helical spring.

To compress the helical buffer-spring and enable the buffer-ram to be fastened in position, or left unfastened.

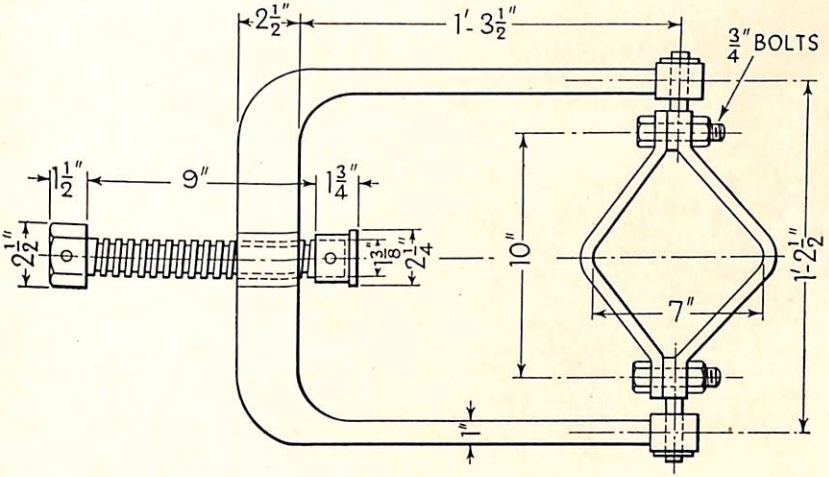


Fig. 4. Buffer-spring Cramp

5. Buffer-spring Jack (Fig. 5)

Double-screw action, which when tightened thrusts the buffer-spring back.

To compress the buffer-spring at one end, thus enabling the buffer-ram shoe to be fitted or taken off.

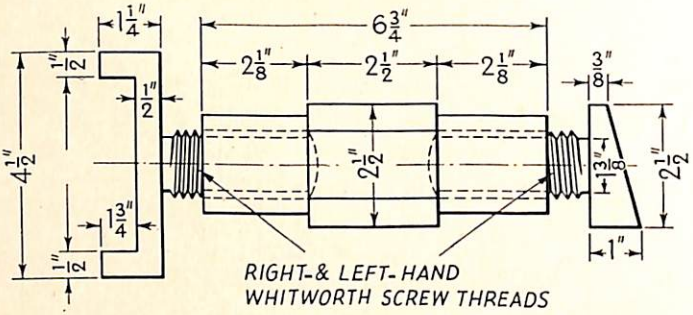


Fig. 5. Buffer-spring Jack

6. Frame-cramps and Body-cramp

To secure in position wagon parts to be fixed and bolted.

7. Axle-guard Leg-cramp

Fitted round the legs of axle-guard where the tightening of screw will force the legs inwards.

To cramp axle-guard legs into the correct position and for fixing of the bridle.

8. Draw-gear and Brakework Spanners

To tighten or loosen nuts.

Oxygen-flame Cutter

An important tool used for—

(1) The stripping of corroded wagon parts.
(2) The cutting to length of steel plates or bars.
(3) In conjunction with pneumatic tools and electric hand-boring machines.

Pneumatic Tools

Rivet-cutter

Used in the cutting of rivets, bolts, and nuts; also when fitted with a drift it can be utilized for the removing of fast draw-bar pins and fast bolts. As this tool is very useful in the stripping of badly corroded wagon parts, it can be classed as essential to both wood and steel wagon repairing.

(1) When in use—
Movable parts must be oiled three or four times each day.
(2) When not in use—
Should be immersed in a bath containing a mixture of paraffin and oil.
N.B. Before using again, after immersion, surplus oil and paraffin should be blown out of the tool by compressed air.

Rivet-hammer (or Pom-pom) No. 1

This is a smaller tool used for the same purpose as the rivet-cutter.

Care as for rivet-cutter.

Rivet-hammer (or Pom-pom) No. 2

This tool is generally used for the clenching of the rivet and also for the moulding of the rivet head to the correct shape, and thus is essential to steel frame repairs, and also for the caulking of plates, cleaning the edges of plates, and the tightening of rivets.

Care as for above.

Air Drill

This can be described as a mobile drilling-machine which is used for—

(1) Reamering holes after the assembly of parts.
(2) Drilling holes in parts which to a fixed machine are inaccessible.

This tool requires frequent oiling and greasing, but immersion in a paraffin bath is not necessary.

Air Grinder

Used for—

(1) The fitting of steel-frame joints.
(2) Where the elimination of cutting edges is necessary.
(3) Where round edges are required.

Care as for air drill.

Holder-up

Where these counterpart tools of the hammer or pom-pom can be used it is advisable to do so, since this will ensure a solid and tight rivet.

Care as for air drill.

Lifting-jacks

Screw-, air-, or electrically-powered jacks, used for the lifting of wagons.

Moving parts must be kept clean and lubricated.

Trammel

Gauge or compass used for the drawing of diagrams and for checking between two points.

CHAPTER II

PROGRESS OF WAGON DESIGN FROM 1800 TO THE PRESENT DAY

THE chaldron wagon—The spring-buffer, 1887 specification—Reconstruction of wooden-buffer to spring-buffer wagons—Conversion of wooden-buffer to self-contained spring-buffer wagons—Standard wood-frame wagon, 1923 specification—Steel-frame wagons—All-steel wagons

THE present design of wagon has evolved from the chaldron wagon pulled by horses along a track of wood.

THE CHALDRON WAGON

All parts used in the construction of this wagon were processed by hand; trees from the local district were sawn, and adzed to the required shape to form the frame-members. The design of frame was generally two sole-bars, the ends of which acted as buffers; two head-stocks tenoned into the sole-bars; and two diagonals which were fitted full length of the frame and tenoned into the head-stocks; they were half jointed at the point of intersection to each other.

All tenon-joints were pegged; hand-made spikes, and nails with iron bands, securely held the parts together. Cast-iron tires were fitted to wooden cart-wheels, rotating on an axle fitted with the ordinary cart bearing. Springs were unknown and hand-forged chains were used for couplings, whilst wooden brake-blocks operated by a simple lever were used to provide braking power.

These wagons had a capacity of between 1 and 3 tons. There was no standard type of construction, as each small colliery or works built the wagons to its own design. The wagons were built by wheelwrights, from the roughest of materials, by hand, and consequently each wagon, despite the flaws, was an accomplishment of individual skill (Fig. 6).

The chaldron type of wagon was, by the process of continuous improvement, strengthened in structural design by the addition of cross-bearers, middle- and end-longitudes, side-rails, iron wheels, efficient bearings, draw-hooks, coupling-links, etc. Thus by 1860 a wooden-buffer railway wagon had been evolved which met the transport needs of the small industries of that period.

The continued improvement in the design and tractive power of the steam locomotive, and improved railway tracks, combined with the increased demand for transport, resulted in trains of

thirty or forty wagons, consequently causing a considerable increase in shunting operations. The wagons had to be uncoupled by hand and then shunted with only one brake, which during wet weather was of very little use, the result being displacement of loads and considerable damage to the goods or loss of minerals carried. This was an economic loss to industry, and a financial liability to the railway concerned.

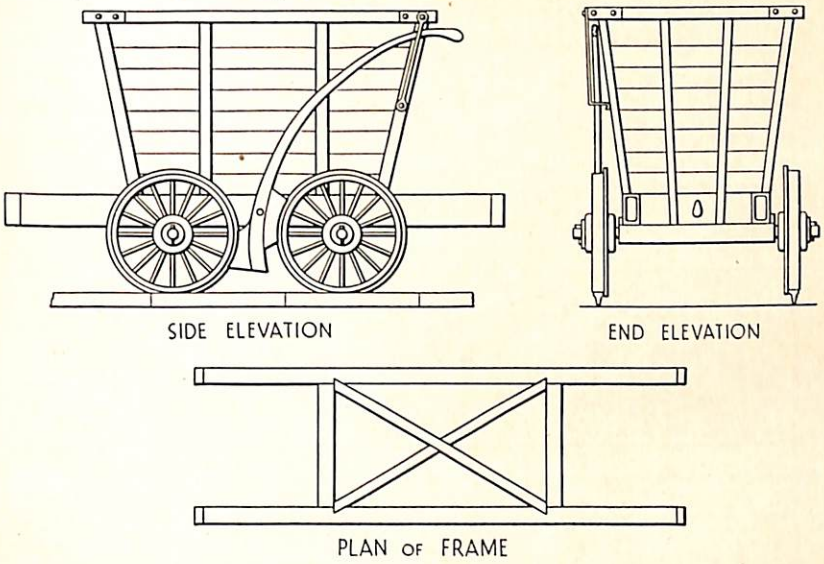


FIG. 6. CHALDRON WAGON ADAPTED FOR RUNNING ON SMOOTH RAILS
Reputed to have been the first railway wagon with four wheels. The illustration is based on an old print, dated 1803.

It was realized that this state of affairs could be remedied by the adoption of a spring-buffer in wagon construction which would absorb the buffer impact. Consequently, about 1880, the railway companies and private owners of wagons agreed to set up a joint committee to consider and examine the design of a railway wagon which incorporated the principle of the spring-buffer, and also several improvements in structural strengths of wagon parts. This committee was named "The Railway Clearing House," and it was decided that all questions relating to constructional details of privately-owned wagons must be submitted to this body, and that the decision given must be conformed to by all parties.

THE SPRING-BUFFER, 1887 SPECIFICATION

In the year 1885 the Railway Clearing House approved the design of a wagon which incorporated spring-buffers and elastic

continuous draw-gear, and which was known as the 1887 specification, to which all future new wagons for the conveying of minerals had to conform. (See Fig. 7.) These new wagons, when

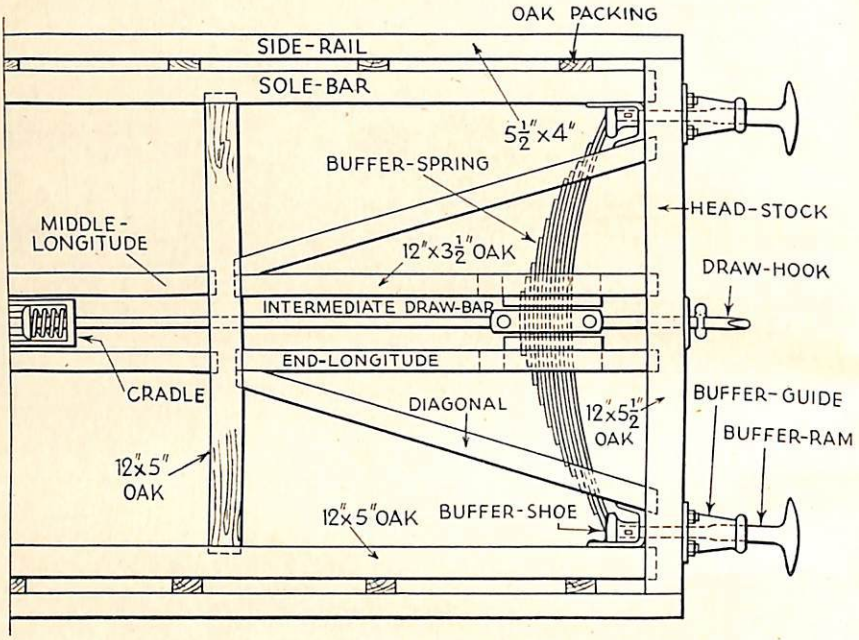


FIG. 7. 1887 SPECIFICATION SPRING-BUFFER

built, were inspected by the railway representative concerned, who, if satisfied that the wagon conformed to the specification and drawings, would fix two register-plates, one on each side of the wagon, which signified that the wagon had been registered by the railway company and accepted for service on their lines.

Main Characteristics of the 1887 Specification

Wheels and axles were made to the standard size, with 6 ft 6 in. journal-centres and the size of journal 8 × 3¾ in.; iron tires, spokes, and axles, the wheels having cast-iron centres.

Axle-boxes designed on an efficient self-lubrication plan, with increased grease-capacity.

Bearings to withstand the increased tonnage carried.

Axle-guards to be 9 in. between legs.

Side-springs secured to the spring-shoes,

Buffer- and draw-springs and their necessary components.

All iron or cast-iron components designed to meet the stress of increased load-capacity.

Frame-members 12 in. wide by 5 in. thick, and subsidiary members 12 in. wide by 3½ in. thick, of oak wood. The width of the frame between sole-bars 6 ft 1 in.

Buffer-centres 5 ft 8½ in.

Wheel-base 9 ft 0 in.; there were some variations allowed, owing to the sharp curves of rail-track existing at that period.

Couplings welded in the draw-hook.

The 1887 specification of the spring-buffer wagon changed the status of the wheelwrights and carpenters who had built the wooden-buffer wagons, as, owing to the specialization of wagon construction, they became members of a new trade—Railway Wagon Building and Repairing.

RECONSTRUCTION OF WOODEN-BUFFER TO SPRING-BUFFER WAGONS

As practically all the railway wagons in service at this period were wooden-buffer wagons, and as the availability of materials and money was restricted, it was impossible to embark on a wagon-building programme which would replace all wagons then in service by the spring-buffer type of wagon. It was, however, considered essential to institute some form of replacement as soon as possible, and consequently it was agreed to reconstruct the wooden-buffer wagons to the spring-buffer type, incorporating in this process the continuous draw-gear. The necessary constructional details to cover this alteration were issued by the Railway Clearing House.

This alteration was classed as a major repair, and necessitated the shortening and re-tenoning of sole-bars and the fitting of new head-stocks. Subsidiary frame-timbers were generally replaced by new ones, or if they conformed to the required thickness were re-shaped and had new under-beds fitted to accommodate the buffer-spring.

Reconstructed wagons, when completed, were examined by the railway companies' inspectors, who, if they were satisfied that the reconstruction had been effected in accordance with R.C.H. Regulations, fixed two register-plates, which signified that the wagon had been accepted for traffic. This process of reconstruction was continued until 1914.

CONVERSION OF WOODEN-BUFFER TO SELF-CONTAINED SPRING-BUFFER WAGONS

Early in 1900 a spring-buffer was evolved, which contained in one unit a buffer-ram, a volute spring, a guide, and a plate to which the buffer-guide was fixed. This buffer as a complete unit was secured to the head-stock by two strap-bolts and two bolts. (See Fig. 8.)

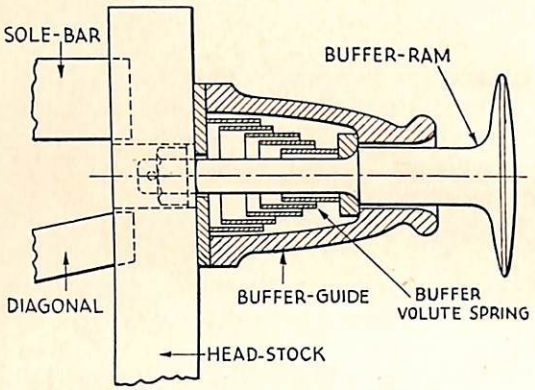


FIG. 8. SELF-CONTAINED SPRING-BUFFER

The Railway Clearing House approved this design of a self-contained buffer, and issued the following instruction for frame alterations when fitting this buffer—

(*a*) Shortening and tenoning of sole-bars.
(*b*) Fixing of the necessary iron parts.
(*c*) Fitting of new head-stocks to which the buffer units were bolted ($5\frac{1}{2}$ in. thick).
(*d*) Incorporation of continuous draw-gear by the fitting of two long draw-bars, one of these to be fitted with a volute spring, stop, and washer; the two draw-bars to be connected by an 18 in. cradle.

The conversion of wooden-buffer wagons to the self-contained spring-buffers was a more economical alteration than reconstruction, as it had the added advantages of the longitudes and diagonals not being weakened by the shaping necessary to accommodate the laminated buffer-spring, and of the self-contained buffers not affecting the varying wagon-frame widths between sole-bars.

These converted wagons were inspected and registered for traffic, in a similar manner to the reconstructs, by the railway companies concerned. It is interesting to note that many thousands of wagons which were reconstructed and converted up to 1914 are still in traffic to-day, despite the fact that 90 per cent were originally built at some time prior to 1887.

STANDARD WOOD-FRAME WAGON, 1923 SPECIFICATION

In 1923 the Railway Clearing House issued specifications and drawings covering the construction of a 12-ton wood-frame wagon.

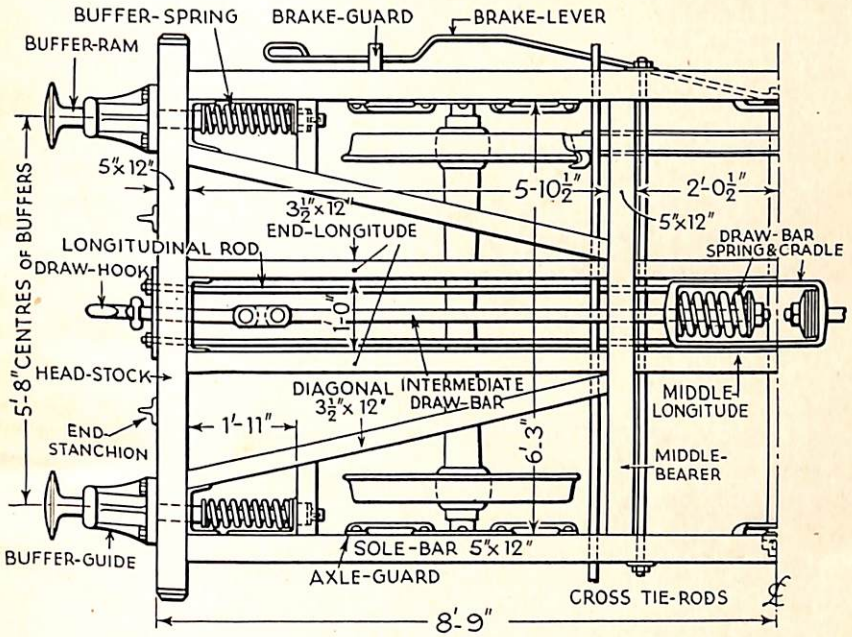


FIG. 9. 1923 STANDARD WOOD-FRAME WAGON

This was, in effect, an attempt to standardize design and to produce a wagon constructed with parts that were interchangeable. This standard design superseded the 1887 specification and all its consequent addenda, and thus after 1924 all wagons were built to the standard design. (See Fig. 9.)

The main principles of this standard construction are—

1. *Width of Frame*

The width of the standard frame is 6 ft 3 in. and owing to this

increase of 2 in. the spring-buffers are built in four separate units, which are composed of—

(*a*) Buffer-rams.
(*b*) Buffer-guides.
(*c*) Buffer helical springs.
(*d*) Buffer rubber springs and washers.
(*e*) Buffer trimmer-knees.

A comparison between the standard buffer-spring unit and the 1887 specification laminated buffer-spring clearly shows that the standard buffer is more economical in costs, maintenance and weight, and has the added advantage of strengthening the frame design.

2. *Draw-gear*

The draw-gear is of the elastic and continuous type and consists of—

(*a*) 2 draw-bar hooks and links.
(*b*) 2 intermediate draw-bars and nuts.
(*c*) 4 connecting-links and pins.
(*d*) Cradle and carriers.
(*e*) Helical and rubber springs and stop.
(*f*) Washers.

These parts when connected and tightly screwed are not attached or fastened to the wagon-frame, and consequently if both draw-bar hooks are pulled out 1 in. from the draw-bar face-plates the wagon should still move freely between the shoulders of the draw-bar hooks.

3. *Wheel-bearings*

Oil lubrication is an important factor when ensuring the efficient running of a wagon, and in the standard wagon this is obtained by metal-lined bearings and by efficient oil-pads and sumps. The axle-boxes used are of the divided type with $2\frac{1}{2}$ in. centres, and these boxes are so designed that the wagon can be completely turned over, during the process of unloading, without the loss of any lubricant.

4. *Wheels*

The wheels of a standard wagon are of steel with journal-centres of 6 ft 6 in. The differences involved by the measurements —axle-box centres $2\frac{1}{2}$ in., journal-centres 6 ft 6 in., and frame-width 6 ft 3 in.—are accommodated by the axle-guards being cranked outwards 1 in.

The original body design of the standard wagon was: length 16 ft 6 in., width 8 ft, but owing to the requirements of industry the sanction of the Railway Clearing House has been given to alter these measurements in certain cases.

STEEL-FRAME WAGONS

In 1889 some wagons were built to the 1887 specification, but a steel frame was used instead of wood. These designs were

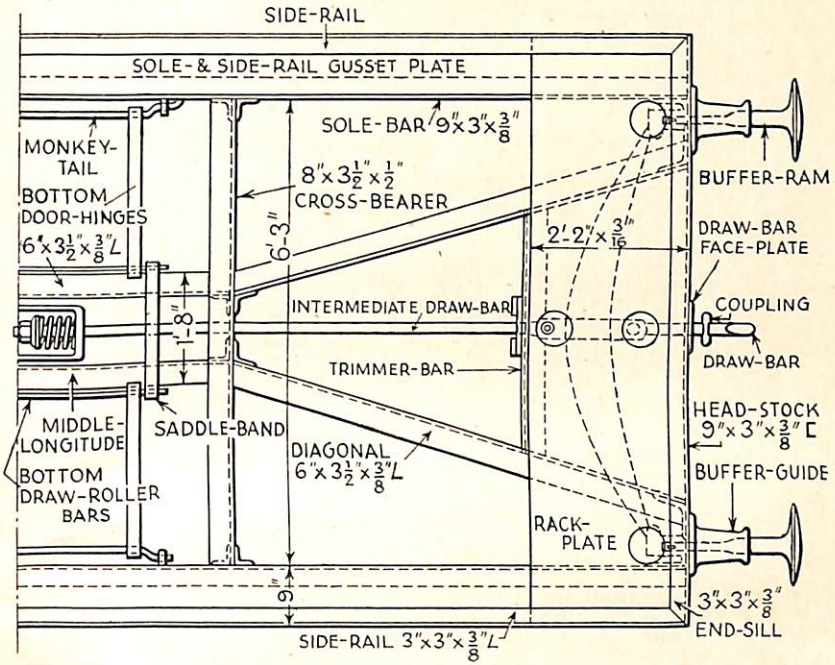


FIG. 10. 1889 STEEL OR IRON UNDERFRAME

approved by the Railway Clearing House, and consisted of the following channels or angles—

(*a*) 2 Sole-bar channels, 9 × 3 × 3 × ⅜ in.
(*b*) 2 Head-stock channels, 9 × 3 × 3 × ⅜ in.
(*c*) 2 Cross-bearer angles, 8 × 3½ × ½ in.
(*d*) 4 Diagonal angles
(*e*) 2 Middle-longitude angles } 6 × 3½ × ⅜ in.
(*f*) 2 Rack-plates, 3/16 in. thick.
(*g*) 2 Side-rail angles
(*h*) 2 End-sill angles } 3 × 3 × ⅜ in.
(*i*) 2 End-pillar tee-irons.

Added to these were the necessary angles and brackets to enable the frame-members to be riveted together. It will be noticed that end-longitudes are not included in this steel-frame construction; these were replaced by rack-plates. (See Fig. 10.)

Standard Steel-frame Wagon, 1923 Specification. The standard design of a wagon issued in 1923 includes a wagon of steel-frame construction, which is much stronger than those built in 1889.

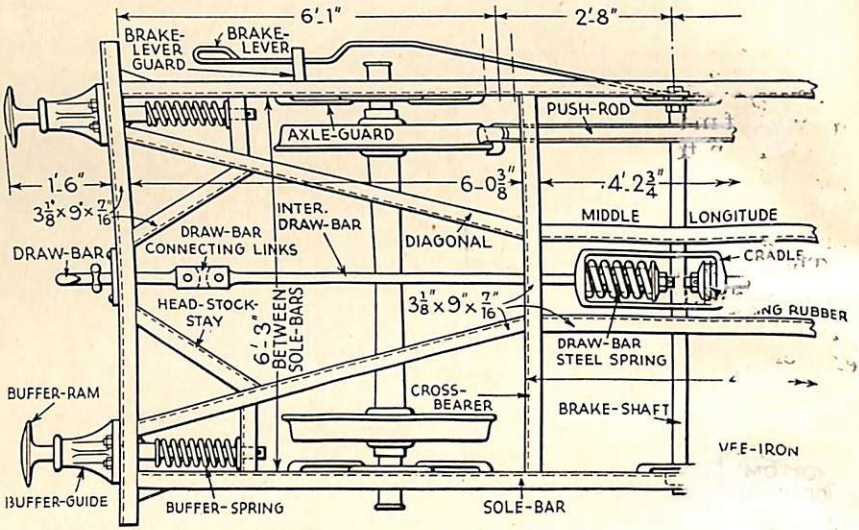


FIG. 11. 1923 ARRANGEMENT OF STANDARD 13-TON STEEL WAGON

The standard steel frame-members are constructed channel 9 × 3⅛ × 3⅛ × 7/16 in., and incorporate the same of buffer and draw-gear as the standard wood wagon. (See

ALL-STEEL WAGONS

There are numerous types of all-steel wagons in traffic today, ranging from 12–40 ton load capacity. Practically all these types have been designed and built to meet individual industrial requirements.

A design of an all-steel wagon, with a load capacity of and a tare weight of 7 tons, for the conveyance of min has been approved by the Railway Clearing House. principles of construction in this design are—

(*a*) Sole-bars, head-stocks, cross-bearers, middle-longitudes and end-longitudes are of steel section 9 × 3⅛ × 3⅛ × 7/16 in.

(*b*) Diagonals are of steel section $7 \times 3\frac{1}{2} \times \frac{3}{8}$ in.

(*c*) Side-knees of a fabricated design are fitted to each side of the wagon.

(*d*) Side-door plates are of a strong pressed design.

(*e*) The end-door is built up of suitable steel channel and angle-irons, or steel plates pressed to a design that will withstand the stresses set up by load movement.

Although the continuous draw-gear has been superseded in this wagon by two short independent draw-bars fitted at each end of the wagon, the real advantage in this wagon lies in the loading capacity and tare weight. Three of these wagons will convey an amount of material which would require four wood-framed wagons. In addition to this, the maintenance costs of all-steel wagons are very small; in fact, if protective coats of paint or impregnations of steel parts with metal alloys are applied when required, the maintenance costs are negligible.

The protection of steel from corrosion is a subject which has awakened considerable interest in the wagon trade, and it is probable that in the future painting as it is known to-day will be entirely superseded by impregnation methods.

CHAPTER III

THE PRINCIPLES OF RAILWAY WAGON CONSTRUCTION

TECHNICAL construction factors—Building a standard wooden wagon by hand—Erection of the wagon-frame

THERE are two chief requirements which govern the construction of new railway vehicles—

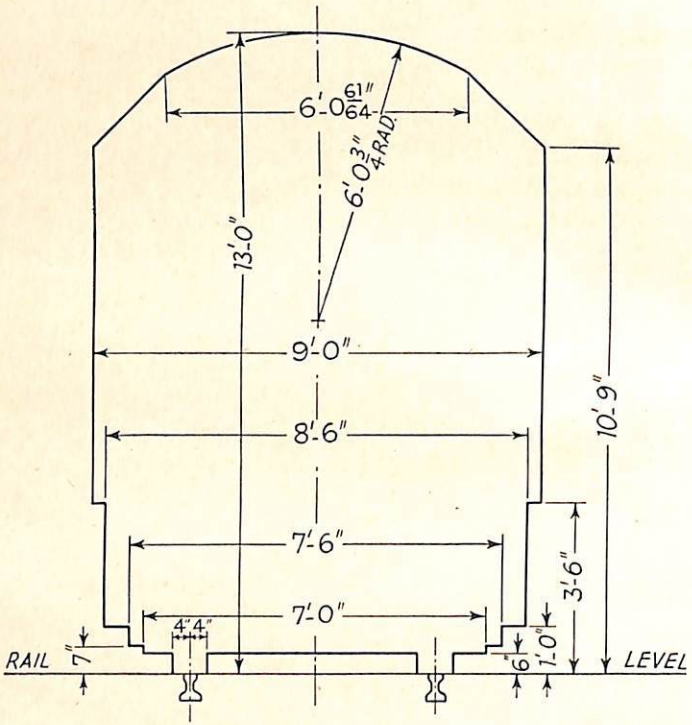


FIG. 12. COMPOSITE CONSTRUCTIONAL GAUGE

A. That they should fulfil the particular function which the vehicle is designed to perform.

B. That they should conform to the dimensional limits of the railway tracks and construction gauges. (See Fig. 12.)

Both factors determine the length, width, and height of the vehicle. The reasons for these dimensions are outlined as relative factors on p. 21.

1. Load-capacity: this is limited to—

(*a*) The carrying-capacity of railway tracks and bridges.
(*b*) The space between parallel sets of railway-tracks.

2. The purpose for which required: the conveyance of minerals, goods, or live stock (and the ton weight to be carried).

3. Cubic capacity of load is arranged to conform to the railway-track construction gauges, and to the facilities operating at loading and unloading stations.

The factors determining the design of the wagon-frame, body and component parts, and the construction of the vehicle, must be in relation to factor (*a*). The vehicle must be sufficiently strongly constructed to meet the required load-capacity; there is here the added advantage that the more strongly the vehicle is built the longer life it will have, with consequent lower maintenance costs. It is essential, however, for the weight of the vehicle to be kept at a minimum, since every pound weight above that which is essential for the required strength is unremunerative weight, which merely imposes a strain on the locomotive.

TECHNICAL CONSTRUCTION FACTORS

1. The width between two wheels fixed to one axle must conform to the width between two parallel sets of rails, comprising one track.

2. The axle is extended through and beyond the wheels to form the journals, which are positioned as near to the wheel as is practicable.

3. The journals are the bearing-points which directly support the vehicle and load, and therefore the axle must be of such dimensions that the length and diameter of the journals formed on the axle can perform their function with efficiency, and have a large safety-margin of strength.

4. The formation of two journals on one axle provides a measurement of distance between the two journal-centres (termed wheel-journal centres), this dimension being the basis upon which all future calculations relating to the width of the wagon-frame are determined.

5. The diameter of the wheels fixed to one axle must be of an agreed dimension, to ensure equality of buffer-heights, and the section and design of the wheels must be in relation to factor *A*.

The wheels have now been sized and journal-centres determined. Two pairs of wheels and axles are required for ordinary wagons, with a load-capacity of 20 tons or less. Wagons with a

carrying-capacity of over 20 tons are generally wheeled with bogie wheel units.

Wheel-base. There are two main factors which determine the position of the two pairs of wheels and axles on the longitudinal plane of the wagon-frame—

1. The radius of the most acute curve of the rail-track upon which the vehicle has to operate. These curves are caused by the physical conditions of the country upon which the rail-track is laid.

2. A balanced distribution of the weight of the wagon, and its ultimate load, which must be supported efficiently by the side bearing-springs, axle-box, bearings, and the wheel-journals to a set buffer-height, this height being applicable to all railway wagons.

To amplify factors 1 and 2: two-wheel units, when fixed to a wagon-frame, should be suitably positioned to travel round the most acute curves with the minimum friction between the tire flange and the track-rails. The buffer-faces also should be of such a diameter that buffer-locking cannot take place.

The wheel-base centres have now been determined by the factors enumerated, which also decide—

(*a*) The position of the middle-bearers in the design of the wagon-frame (within the limits of the middle-bearers fouling the wheel-tires).

(*b*) Supporting brakework components are fixed to the ordinary type of wagon.

These factors in turn determine the centres of the side-body knees and the possible width of the side-doors.

A SUMMARY of the foregoing constructional factors is as follows—

1. The purpose of the wagon.
2. Width of rail-track.
3. Position of two wheels fixed to one axle must conform to 1.
4. Formation of two journals on the axle.
5. The distance between the centres of two journals formed on one axle.
6. The diameter of wheels, and their components, to conform to an agreed dimension of buffer-height from the rail-track.
7. The limitations of lengths, widths, and heights.
8. The position of two pairs of wheels and axles fixed to a rectangular frame, in the longitudinal plane.

9. The structural design of the centre of the wagon-frame has been outlined. Factors 1, 2, and 3 are the stages of progress to attain factors 4 and 5, which are the basis of constructional continuity. The formation of two journals on one axle determines the axle-box and bearing design, which is governed by the length and diameter of the journals; other essential purposes to be embodied in the axle-box design are covered in Chapter IV. There is, however, one constructional detail in the forming of the axle-box which is of importance, namely, the position of the axle-guard grooves in relation to the centre of the wheel-journal.

To find this dimension the important factors are—

(*a*) Wheel-journal centres.
(*b*) Width of side bearing-springs.
(*c*) Clearance space between axle-guard and bearing-spring.
(*d*) Thickness of axle-guard.
(*e*) Formation of axle-guard grooves in the axle-box must be sized to allow for the free working of the axle-guard required for the lateral movement of the bearing-springs when elastically supporting the wagon and load.

It is necessary at this stage of construction to stress that bearings, axle-boxes, and bearing-spring centres must be positioned to the horizontal and longitudinal *centres* of the wheel-journal. The dimensional centre of the axle-box is determined by factor (*e*). Figures will be quoted to amplify the explanation, but any other series of figures could be used, the principles remaining the same—

(*a*) Wheel-journal centres 6 ft 6 in.; half = 3 ft 3 in.
(*b*) Width of side bearing-spring, 4 in.; half = 2 in.
(*c*) Clearance space between one axle-guard and bearing-spring = $\frac{1}{2}$ in.
(*d*) Thickness of one axle-guard = $\frac{3}{4}$ in.
(*e*) Clearance between each side of axle-guard and the grooves formed in the axle-box, $\frac{1}{8}$ in. = $\frac{1}{4}$ in.

Add factors (*b*) and (*c*) together = $2\frac{1}{2}$ in., which is the position of the front face of the axle-guard from the wheel-journal centre, and is also the dimensional centre of the axle-box.

Deducting from $2\frac{1}{2}$ in. the clearance space of $\frac{1}{8}$ in. leaves $2\frac{3}{8}$ in.

Add together factors (*d*) and (*e*) = 1 in.

Thus the position of the axle-guard grooves to be formed in the design of the axle-box, measuring from the centre of wheel-journal = $2\frac{3}{8}$ in. and $3\frac{3}{8}$ in.

The width between two axle-guards positioned on the horizontal plane of the wagon-frame = 5 ft 11½ in., obtained by adding together the doubled factors (*b*), (*c*), (*d*), and deducting from factor (*a*) the figure obtained.

The width to the outside faces of the axle-guards would be 5 ft 11½ in., plus the thickness of two axle-guards 1½ in. = 6 ft 1 in.

Width of Wagon-frame. The width between sole-bars can be adjusted within the limitations of the bearing-springs efficiently supporting the wagon and load. If adjustments are made, the axle-guards must be shaped to ensure that the bearing-spring has free lateral movement.

The wagon-frame width is obtained as follows—

(*a*) Find the dimensional centre of the axle-box = 2½ in. and double the measurement obtained = 5 in.

(*b*) Deduct factor (*a*) from wheel-journal centres, 6 ft 6 in. = 6 ft 1 in.

The figure 6 ft 1 in. is the width between two sole-bars, if the axle-guards are fitted to the sole-bars in a straight position.

A Continuation of the Summary is—

10. Axle-box and bearing.
11. Finding the position of axle-guard grooves to be formed in the axle-box design.
12. Obtaining the dimensional centre of the axle-box.
13. Finding the width between sole-bars.

Construction Principles of the Wagon-frame. The finding of the width between two sole-bars determines the shoulder-tenon length of the middle-bearers, and the intermediate wagon-frame members are positioned to withstand the stresses of—

(*a*) Draw-bar impetus.
(*b*) Buffer-impact.
(*c*) Supporting the load.

The Sizing of Mineral-carrying Capacity. It is obvious that the first essential requirement when building a wagon is to know the purpose of the wagon and the tonnage to be carried. The length of the wagon is obtained as in the following example—

A wagon is required to carry 16 tons of a material which occupies 40 cub ft per ton weight. The width of the wagon-body

is 8 ft 0 in., the height is 5 ft 0 in.; then the length of the wagon-body is derived from the familiar formula—

$$C \text{ (cubic capacity)} = L \text{ (length)} \times W \text{ (width)} \times D \text{ (depth)}$$

$$16 \times 40 = L \times 8 \times 5 \text{ ft}$$

$$\therefore L = \frac{16 \times 40}{8 \times 5} \text{ ft} = 16 \text{ ft}$$

The size of the wagon, in conjunction with the wheel-base centres, and in relation to the curve of the rail-track, also fixes the diameter of the buffer-ram heads.

The difference between the width of the wagon-frame and that of the wagon-body is allowed for by fitting suitable packings, termed side-rails, to the sole-bars.

SUMMARY CONTINUED—

14. Structural design of the wagon-frame.
15. The sizing of the wagon-body.

Unloading facilities and the shape of wagons intended to perform special functions do not affect the principles outlined.

The basis of railway-vehicle construction is as described at the beginning of this chapter, subject to the limitations of factors *A* and *B*. These fundamental principles of wagon construction are the basis of the wagon designs, which after processes of drafting are eventually presented to the Railway Clearing House. If these designs are approved, the outcome is the concern of the railway-wagon building industry, which comprises a number of works specially equipped for this kind of production. The methods employed in these wagon-building works depend upon the facilities available. Some workshops are highly mechanized, whilst the very opposite conditions sometimes apply in other workshops. The method of assembling wagons varies considerably between workshops, owing to the varying availability of plant and its capacity to produce the component parts required. It is essential, however, that the apprentice should know the technical principles involved in building a wagon, the methods of setting and marking out the component parts of the wagon, finally shaping the parts to fit to each other (the skilled use of tools is of the utmost importance), assembling, squaring, and checking all points as the wagon is erected. These principles of practical construction are outlined in the following pages.

BUILDING A STANDARD WOODEN WAGON BY HAND

The factors enumerated are to the 1923 specification, but the principles are applicable to any type of wooden wagon built to a similar design. The wagon-frame members are positioned on building trestles and sized, the first operation being to mark on these timbers the positions of tenons, mortises, bolt- and rod-holes, and the various shapes required to fit steel components. (See Fig. 13.)

The principal points to be observed in marking and setting out the wagon-frame timbers are—

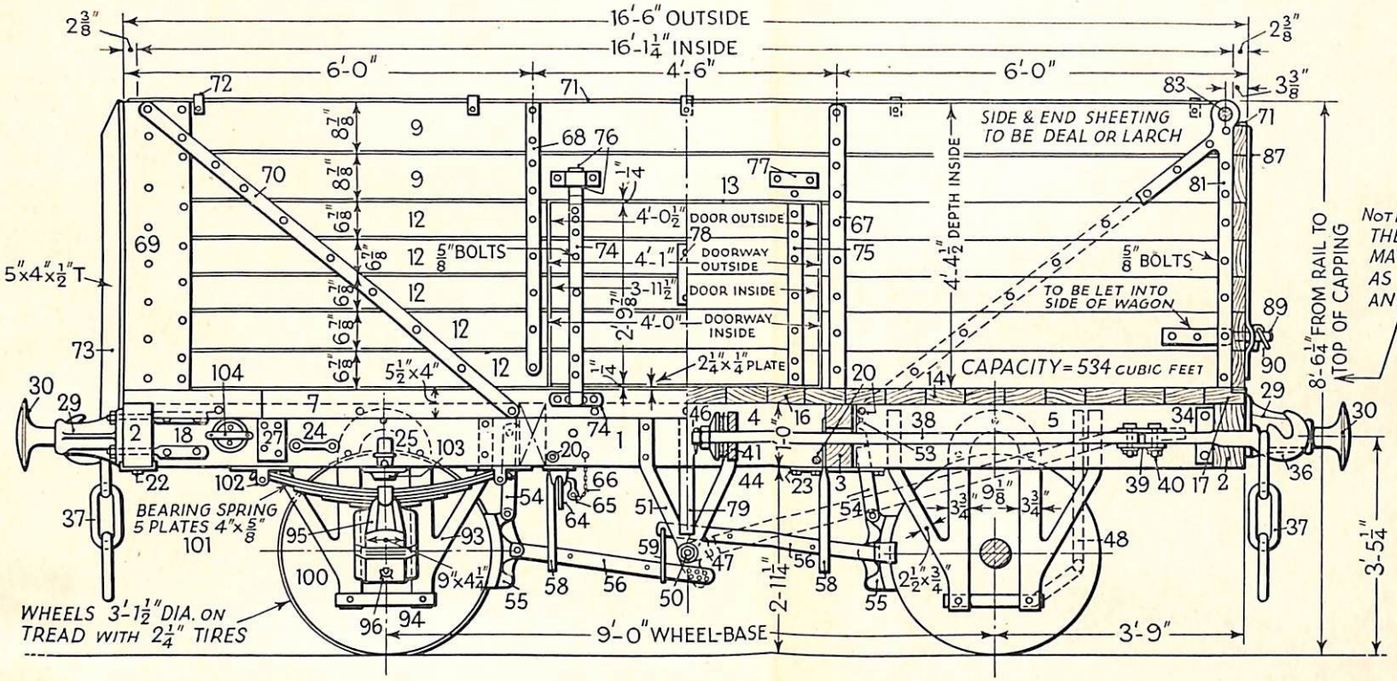
1. The correct use of the try-square, scriber, or pencil.
2. Meticulous care in reading the ruler or steel tape-measure.
3. Very careful attention to detail.
4. Hand-tools must be in perfect condition.
5. When commencing to mark out the frame-members, examine the faces of the timbers and choose the best faces for the front and bottom. All frame-members should be clearly marked to indicate the position of faces when fixed in the wagon-frame.
6. If the sole-bars are slightly bowed longitudinally, mark the concave edge to be the top face (if this bend is more than $\frac{1}{2}$ in. it is advisable to reject it as unsuitable).

Marking Out the Wagon-frame. To mark out the sole-bars—

1. Measure the length and find the longitudinal centre.
2. With the aid of a try-square, mark and square this centre-line round all faces of the sole-bar. This centre-line is the basis of all future measurements and should be accurately obtained.
3. Set out the inside face of sole-bar measuring outwards from the centre-line, marking—

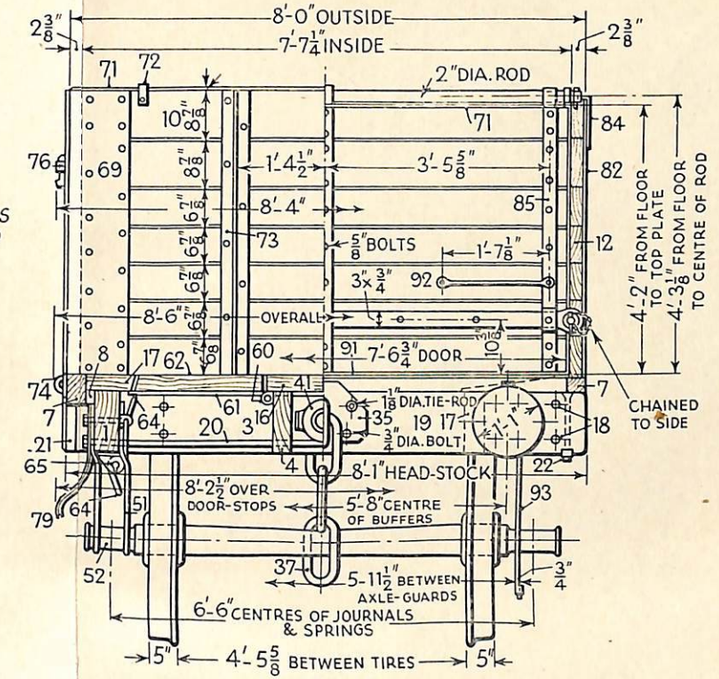
(*a*) The width between, and thickness of, the middle-bearers.
(*b*) The wheel-base centres.
(*c*) The length of sole-bar between tenon-shoulders.
(*d*) The length of tenons.

4. From the sole-bar centre-line, mark the position of the side-door stop-spring, brakework, monkey-tail eye-bolts, cross-rods, and side-rail bolt-holes.
5. From the wheel-base centre-lines measure and carefully mark the position of the axle-guard bolt-holes.
6. Measuring from the sole-bar tenon shoulder-lines, mark the position of the strap-bolts, trimmer-knee, and horse-hook bolt-holes.



SIDE ELEVATION

LONGITUDINAL SECTION



HORIZONTAL SECTION

END ELEVATION

FIG. 13. STANDARD 13-TON WAGON

Drawing No. 1002, April, 1923.

Wood Underframe Components

1. Sole-bar.
2. Head-stock.
3. Middle-bearer.
4. Middle-longitude.
5. End-longitude.
6. Side-rails.
7. Side-rail packings.

Wood Body Components

9. Side through-planks.
10. Fast end.
11. End-door.
12. Side-quarter.
13. Side-door.

Wood Floor

14. Floor-planks.
16. Bottom-door saddle.
17. Bottom-door and end-sills.

Steel and Iron Underframe Components

18. Strap-bolts.
19. Longitudinal through-rods.
20. Cross-rods.
21. Head-stock hoop.
22. Head-stock clip.
23. Longitudinal tie-plates.
24. Horse-hooks.
25. Ticket-clip.

Buffer-gear

27. Trimmer-knee washer-plate.
29. Buffer-guide.
30. Buffer-ram.

Draw-gear

34. Head-stock and longitude knee.
35. Draw-bar face-plate.
36. Draw-bar hook (gedged).
37. Draw-bar coupling (gedged).
38. Draw-bar intermediate.
39. Draw-bar connecting-links.
40. Draw-bar pins.
41. Draw-bar cradle.

Brakework

47. Brake-lever.
48. Brake-guide.
50. Brake-spindle.
51. Brake vee-irons.
52. Vee-iron spacing-ferrule.
53. Brake-bracket.
54. Brake-block hangers.
55. Brake-block.
56. Brake push-rods.
58. Brake-carriers.
59. Brake centre safety-loop.

Bottom-door

60. Hinge saddle-band.
61. Hinge.
62. Hinge washer-plate.
64. Monkey-tail.
65. Monkey-tail bracket.
66. Monkey-tail peg and chain.

Steel Body Components

67. Side-knees.
68. Side-knees washer-plates.
69. Corner-plates.
70. Diagonal side-braces.
71. Capping.
72. Capping-clip.
73. End-stanchion.

Side-door.

74. Hinge.
75. Hinge washer-plate.
76. Hinge-fastener.
77. Hinge-fastener washer-plate.
78. Door striking-plate.
79. Door stop-spring.

End-door

81. End-door knees.
83. End-door roller-bar.
84. End-door roller-bar stop.
85. End-door hinges.
86. End-door hinges spacing-ferrule.
87. End-door hinges washer-plate.
89. End-door fastening-bar bolts.
90. End-door pegs and chains.
91. End-door sill-plate.
92. End-door commode-handle.

Carriage

93. Axle-guard.
94. Axle-guard bridle.
95. Axle-box top section.
96. Axle-box bottom section.
100. Wheels.
101. Side bearing-springs.
102. Side bearing-springs shoes.
103. Side bearing-springs stop.
104. Railway register-plate.

7. Measuring from the bottom face of the sole-bar, mark the spacing of sole-bar tenons and mortises for the middle-bearers.

8. Turn the sole-bar over to enable the bottom face to be marked out; continue the wheel-base lines across this face; and, measuring from these lines, mark the position of bearing-spring shoes, stops, bolt-holes, and coach-screw holes.

9. From the centre of the sole-bar, mark the position of coach-screw holes for the bottom-door fastener.

10. Turn the sole-bar over to mark out the top face, and from the tenon shoulder-line measure and mark the position of the end knee-foot bolt-hole; from the centre-line of the sole-bar measure and mark the side knee-feet bolt-holes; square the wheel-base centre-line across this face, measuring from the inside-face mark $2\frac{1}{2}$ in., and centre-pop dead on this mark (the centre-pop mark is made to enable the frame to be correctly trammelled to test square position of frame).

N.B. The lines positioning tenons marked on the inside face must be continued and squared across the ends of the sole-bar to the front face, unless they are to be formed with a tenoning-machine.

The Middle-bearer. The same principles are followed as in the sole-bar—

1. Choose and mark the faces.
2. Find and mark the centre.
3. Inside face: measuring from the centre-line—

(*a*) The width between, and the thickness of, middle longitudinals.
(*b*) The tenon shoulder-length (width of wagon-frame).
(*c*) The length of tenons.

4. From the tenon shoulder-lines measure and mark the position of the brakework bolt-holes.

5. From, and on, the centre-line measure the position of the longitudinal tie-rods and intermediate draw-bar hole.

6. Measuring from the bottom face of the middle-bearer, mark the spacing of the middle-longitude tenons and middle-bearer tenons.

7. Marking out the top face of the middle-bearer, continue the tenon shoulder-lines across this face, and measuring from these lines, mark the position of the side knee-feet bolt-holes.

8. Marking out the front face, measuring from the centre-line,

mark the position and thickness of the end-longitudes and diagonals, less $\frac{5}{16}$ in. of the combined width of these members; this allowance enables the diagonal side of the mortises to be inclined to the correct angle of the diagonal tenon as it is positioned when fixed in the wagon-frame. Also continue the shoulder-lines across this face.

9. Measuring from the bottom face, mark the spacing of the end-longitude and diagonal tenons, and also the spacing of the middle-bearer tenons, and continue these lines across the ends of the bearer.

The Head-stock.

1. Mark all faces and centre this frame-member.

2. Mark out the inside face: measuring from the centre-line, mark the position of—

(*a*) End-longitudes.
(*b*) End-stanchions.
(*c*) Buffer-centres.
(*d*) Diagonals.
(*e*) Sole-bars.
(*f*) Head-stock hoops (if fitted).
(*g*) The overall length.

Square and line in all the above marked positions across the face of the head-stock.

3. Measuring from the buffer centre-lines, mark the position of the strap-bolts, buffer-ram, and buffer-guide bolt-holes.

4. Mark the outline of the draw-bar hole, as follows—

(*a*) Measure 6 in. from the top face, and mark through the centre-line.
(*b*) Measure from (*a*) towards the top face $1\frac{1}{8}$ in.
(*c*) Measure from (*a*) towards the bottom face 2 in.
(*d*) Measure and mark either side of the centre-line $1\frac{1}{16}$ in.; square lines on these marks across the face of the head-stock.

5. Mark out the top face: as the head-stock is turned over to this face, continue the hooping-lines across this face.

6. Obtain the position of the end knee-feet bolt-holes by measuring from the centre-line and marking half the width of wagon between the side planks, marking this dimension on the top face of the head-stock. The distance these holes are from the front face of the head-stock is dependent on the possible thickness of the head-stock and the end-door planks; with the

fitting of an end-door made up of planks $2\frac{1}{2}$ in. thick the end-knee is straight, but the feet-holes are drilled $\frac{1}{4}$ in. out of centre (if an end-door 3 in. thick was fitted, the knee would need to be heated and cranked): the distance from the front face of the head-stock to the centre of knee-feet bolt-holes is $3\frac{3}{8}$ in.

N.B. Side-knee bolt-hole positions are obtained by the same method, with obvious adjustments.

Middle- and End-longitudes

1. Marking out the top face, measure the length of the tenon from one end, and square this shoulder-line across the face.
2. From this shoulder-line measure the length between the shoulders and the length of the tenon.
3. Square these lines on the positions marked across the face, and continue on all faces, and from the applicable shoulder-lines measure and mark all rod- and bolt-holes.
4. Mark out on the bottom face the position of the longitudinal plate bolt-holes, also the spacing of tenons, and square these tenon-lines on the ends of the longitude.

The Diagonal

1. Mark the top face, and number.
2. There are two methods of obtaining the length—

(*a*) From a template prepared when the frame is erected (minus diagonals).
(*b*) From a diagram drawn full scale depicting the correct position of the diagonal as it fits in the wagon-frame.

3. The positions of bolt- and rod-holes are measured from the applicable shoulder-lines.
4. The spacing of tenons is measured from the bottom face of the diagonal and marked at sides and ends.

N.B. It is customary to plane all rough edges off frame timbers and tenons.

Side-rail

1. Mark all faces.
2. Measure and mark the centre of this member on all faces.
3. Place the side-rail on the sole-bar with the centre-lines of both members contacting.
4. Continue the bolt-, rod-, and shoulder-lines marked on the sole-bar to the front face of the side-rail.

5. Measuring from the half-tenon shoulder-lines, mark the thickness of the head-stocks.

6. Measuring from the overall-length line, mark the position and size of the mortise to accommodate the end-door knee.

7. Measuring from the centre-line of side-rail mark—

(*a*) The centres of side-knees.
(*b*) Size of mortises.
(*c*) Side-door hinge-feet bolt-hole centres.
(*d*) Side-door nosing bolt-hole centres.
(*e*) Side-door sill-plate rebate.
(*f*) The width of the side-doorway, 4 ft 1 in. outside.

8. Measure and mark the depth of the tenon-shoulders from the top face of the side-rail (thickness of floor-planks).

9. Continue the lines marking the positions of side- and end-knee mortises from the front face to the top face, and measure the distance these mortises are from the front face (thickness of side-planks), also the width of side-door sill-plate.

10. Measure and mark the position of the chamfers and split-bolt holes.

11. On the bottom face, measuring from the centre-line, mark the positions of the sole-bar and side-rail bracket bolt-holes.

The marking and setting out of the wagon-frame is now completed. The important factors are those outlined in the beginning, with particular stress on obtaining with absolute certainty the "centre" of the member to be marked.

ERECTION OF THE WAGON-FRAME

A method of erecting the wagon-frame when mechanized aid is not available is as follows—

1. Commence by painting the joints and the places where iron and steel components are to be fitted.

2. Fit and fix on the sole-bars, spring-shoes, stops, monkey-tails, and fasteners.

3. Position both sole-bars in alinement with the rail-tracks, and about 6 ft 4 in. between, and place a screw-cramp over both sole-bars, which prevents the sole-bars falling over and also is an essential tool, in all stages of frame erection, to cramp joints together.

4. Open the sole-bars at one end to a width of approximately 7 ft, and enter the tenons of a middle-bearer into the mortises provided in the sole-bar, aline the bearer to the mortises of the

other sole-bar, and ease this sole-bar on to the bearer-tenons; place the cramp over this bearer and lightly tighten.

5. Fix in position the middle-longitudes, supporting these with the short cross-rods.

The remaining middle-bearer can now be fitted in position.

(*a*) Place one tenon-end of the bearer into the mortises of one sole-bar.

(*b*) Position the longitudes in alinement with mortises cut in the bearer, and cramp the bearer into the longitude-tenons.

(*c*) When the bearer is in alinement with the mortises cut in the other sole-bar, cramp this sole-bar on to the bearer-tenons, lightly screw up the cross-rods, with a staff trammel the frame diagonally between the insides of the middle-bearer shoulders, correct any divergence from a square position, tighten up rods, and cramp.

N.B. Test the levelness of the frame at this point, as it is easier to make corrections at this stage than when the frame is practically completed.

7. Fit and bolt on the frame parts erected all the steel components that can be fixed.

8. Fit and bolt in position the diagonals, following with the end-longitudes and longitudinal tie-rods.

9. Check over the head-stock in order to ensure that all mortises are spaced to correspond to the tenons of sole-bars, diagonals, and longitudes (otherwise the result will be the splitting of these frame-members by forcing the tenons into inaccurate mortises); cramp the sole-bars to a bare 6 ft 3 in. between; fix the buffer-guide bolts in the diagonal knees; place the head-stock on the longitudinal rods; guide the buffer-casting bolts into the head-stock; and cramp the head-stock into position.

10. Fix on the frame all iron and steel components. When completed, test the levelness of frame, set the trammel to the centre-pop holes on the top face of the sole-bar positioning the wheel-base, and test the square position of the wagon-frame (or from the inside of sole-bar shoulders at each corner of the frame).

It is now assumed that the frame has been levelled properly, that the axle-guards are hanging squarely, and that the frame is in an accurate square position, so the following points should next be checked—

(*a*) Width between sole-bars is 6 ft 3 in.

(*b*) Trammel the axle-guards longitudinally from the centre-line of wagon-frame, and in a diagonal direction top and bottom of the axle-guards' legs.

(*c*) Centres of bearing-spring shoes are 6 ft 6 in. (horizontal position).

(*d*) Centres of buffers, 5 ft 8 in.

(*e*) Length of buffers from the front face of head-stocks to the face of the buffer-ram, 1 ft 6 in.

(*f*) Length of buffer-ram stroke, $4\frac{1}{2}$ in.

(*g*) All joints are a good fit.

Having completed the wagon-frame, fix in position—

(*a*) Side-rails, (*b*) end-stanchions, (*c*) side- and end-knees, (*d*) sill-planks and floor-planks.

The Fixing of Bottom-doors

1. Fit in position the bottom-door-knee floor-planks.
2. Fit in position the bottom-door-sill planks.
3. Fit in position the bottom-door-saddle planks.
4. Fit in position the bottom-door planks.
5. Position the door-planks with wedges, ensuring a $\frac{1}{4}$ in. clearance gap all round the door.
6. Using the hinges as templates, place these in the correct position and bore holes through the planks, after which the washer-plates should be rebated into the top face of the door-planks. The door is now ready for bolting together.

Erection of the Fast End

1. Continue the centre-line of the head-stock to the end-sill.
2. Fix in position the end-stanchions.
3. Obtain the centre of one fast-end plank and square this line across the face of the plank.
4. Place the end-plank in position on the end-sill, centre-lines contacting, and fasten to this position by one nail to the end-stanchion.
5. Place the other end-planks in alinement with the first plank.
6. Place a cramp over the end and head-stock, and lightly tighten.
7. If there is any doubt whether the end is not truly square, check by trammelling diagonally from the corner. The probable cause of lack of squareness would be a plank not sized evenly.

Marking Out Side of Body

The length of side-planks should be $\frac{1}{16}$ in. longer than the length of the wagon over the head-stocks, to allow for the dressing

of the ends of side-planks when the side is erected. The composition of one side is—

(*a*) 5 side-planks $6\frac{7}{8}$ in. width.
(*b*) 2 side-planks $8\frac{7}{8}$ in. width.

The basis of all measurements required to mark out the side is measured from the transversal centre of the wagon-frame; this centre-line is already marked on the side-rail.

1. Measuring from either side of this centre-line marked on the side-rail—

(*a*) Mark the width of side-doorway, outside 4 ft 1 in., inside 4 ft 0 in.
(*b*) Mark the length of side-door, outside 4 ft $0\frac{1}{2}$ in., inside 3 ft $11\frac{1}{2}$ in.
(*c*) The width between side-knee centres, 2 ft 3 in. from the centre-line of the wagon, 4 ft 6 in. between knees.
(*d*) Square all these lines across the front face of the side-rail.

2. Procure a wooden staff the same length and width as the side-planks, about $\frac{3}{4}$ in. thick; place the staff on the top face of the side-rail, and level with the front face and the door-end of the side-rail.

3. Continue the lines marked previously on the side-rail to this staff.

4. Join these lines across the top face of the staff (it is an advantage to make a small saw-cut on these lines, thus preparing a template of the side-doorway and side-door that can be used innumerable times; it must be accurate, however).

5. Choose a straight-grained plank for the No. 1 side-plank, place the template on the top face of this plank $\frac{1}{16}$ in. short at the end that will be fixed to the door-end of the wagon-body (this allowance is to enable the end of the plank to be dressed properly), mark off the plank from the template, and square these lines across both the side faces of the plank.

6. Follow the same procedure with side-planks Nos. 2, 3, 4, and 5. No. 1 side-plank requires recessing $\frac{1}{4}$ in. on the bottom face (the door clearance space). Measure the distance between the top face of the side-rail and the centre of the first bolt-hole of the side-knee, and, measuring from the bottom face of the plank, mark the distance obtained on the side-knee centre-lines. No. 1 plank is now ready for recessing and boring.

7. No. 2 plank accommodates the end-door fastening-bolt, and to obtain the position of this bolt—

(*a*) Measure the distance between the top face of the side-rail and the second hole in the end-door knee.

(*b*) Deduct $6\frac{7}{8}$ in. from the measurement obtained (the width of No. 1 plank).

(*c*) The remainder is the centre of the end-door bolt-fastener as measured from the bottom face of No. 2 plank.

(*d*) The distance of the first bolt-hole of the fastener from the end of the side-plank is obtained by measuring the thickness of the end-door planks and adding half the width of the end-knee.

8. Nos. 3 and 4 planks require marking from the template, and need lines squared across both sides.

9. No. 5 plank occupies the position of the top plank in the side-door, and requires to be recessed for clearance space at the top face. This recess should be bevelled downwards towards the inside face of the plank. To enable the door to be sawn through the side when this is erected, previous to fixing the plank in position, saw along the lines positioning the width of the side-door, approximately 4 in. deep, after which the recessing can be done.

10. No. 6 plank requires marking from the template only.

11. No. 7 plank requires marking from the template. As this is the top side-plank, it must be shaped to accommodate the end-door rod and accessories. To obtain the size of the shape to be cut out of the plank—

(*a*) Measure from the end of side-rail to the inside edge of the end-door knee; mark the distance obtained on the plank, measuring from the door-end of the plank.

(*b*) The thickness of the piece to be cut out is obtained by measuring the distance between the centre of the end-door rod-hole shaped in the end-knee and the top face of the side-rail. Deduct from the measurement obtained the combined widths of the side-planks Nos. 1 to 6, plus $1\frac{1}{2}$ in., and the remaining figure is marked on the plank, measured from the bottom face, and positions the depth of piece to be cut out of the side-plank.

Erection of the Side. The side is erected by nailing each plank to the centre of the corresponding fast-end plank. Side-planks that are of a concave shape lengthwise should be lifted up at the door-end of the plank until the bottom face of the plank lies flat and solidly fits the side-rail or the previous side-plank. Having

erected both sides and nailed each plank securely, place a cramp over both sides, opposite the side-body knees; then, using two short sheeting-cramps placed on the top of the side-planks to the bottom face of the side-rail and about 3 ft from each end of the side, with light pressure cramp the side down to the side-rail. Before finally tightening the cramps, make certain that all the lines marked on the planks to position the side-door join each other; when this is so the cramps can be fully tightened.

N.B. If there is any difficulty in positioning the side-planks, loosen the end-stanchion bolts of the end-planks concerned. If there is any doubt whether the side is square, it is advisable to trammel from the ends of the top side-planks to a point marked on the centre of the side-rail.

The side is now ready to be fastened to the body-knees and banded.

To fasten the side-planks to the side-knees—

1. Place the bottom bolt of the side-knee in position (this hole was bored in No. 1 plank during preparation), and loosely place on the bolt the side-knee washer-plate.
2. Position the washer-plate on the side-knee centre-lines marked on the side-planks.
3. Using the washer-plate as a template, mark the positions of side-knee bolt-holes.
4. Remove the washer-plate and bore the holes marked on the side-planks from the washer-plate.
5. Bolt and fasten the side-planks to the side-knees.
6. Position the end-knee, according to the thickness of the end-door planks; and bore, through the top hole of the knee, the top side-plank, and fit a bolt in this hole.
7. Place the end-knee washer-plate on this bolt and use the plate as a template to mark the position of the remaining bolt-holes, also positioned in conjunction with the body-brace.
8. Fasten and bolt in position—

(*a*) The corner-plate in conjunction with the body-brace.
(*b*) The side-door hinges, fasteners, and striking-plate.

9. The side-door can now be sawn out of the side by placing the saw in the saw-grooves sawn in the preparation of No. 5 plank for this purpose, and sawing down the lines marked on the side-planks.
10. Plane all rough edges off the planks and fix in position the end-door bolt-fastener.

11. Place the cappings in position, and fasten with screws and clips to the top planks.

The Erection of the End-door. The length of a prepared end-door plank is $\frac{1}{2}$ in. shorter than the length of a fast-end plank to ensure a clearance gap between the end of the planks and the sides of the wagon-body. It is advisable to allow $\frac{1}{8}$ in. for dressing the ends of the planks. The method of erecting the end-door is—

1. When fixing the end-door tie-rod (or roller-bar) in position, see that—

(*a*) The hinges hang squarely on the tie-bar.
(*b*) The end-door-fastening bolt-holes drilled in the end-knees are in alinement with the fastener-bar bolt-holes punched in the end-door hinges, or vice versa.

If the end-door iron or steel components are faulty, the fitting of the end-door is made very difficult, and the probable result will be a twisted or deformed door.

2. These precautions having been taken, the door can be fitted together. Place clearance packings $\frac{1}{4}$ in. thick on the end-door sill-plank.

3. Place the door-hinges close up to the end-door spacing-ferrules, place the fastener-bar in position, and centre the bolt-holes in the hinges to the fastener-bar.

4. Place the first plank in position on top of the clearance packings, spaced evenly at each end and with the hinges hanging true. Mark the position of bolt-holes from the hinges to the plank.

5. The holes thus marked are then bored, the plank replaced, and bolts placed in the hinges and plank; the hinge washer-plates are then placed on these bottom bolts. Remove the fastener-bar.

6. This plank is then followed by all the other planks comprising the end-door. To prevent the planks from falling out, place a brake push-rod carrier over the hinge-rod and door planks.

7. Adjust all planks to the correct clearance space, then cramp them tightly down.

8. Use the washer-plates as templates and mark the position of hinge-bolts. The holes so marked are then bored, and the planks, hinges, fastener-bar, and washer-plates are bolted together.

9. The fastener-bar bolt-holes are bored and bolts fitted, after

which the end-door can be swung out sufficiently to enable the ends of the planks to be dressed.

N.B. When fitting an end-door, the important points are—

(*a*) To see that the hinges hang correctly and are seated properly on the hinge-rod (or roller-bar).

(*b*) That the centres of the end-door fastener-bar bolt-holes are centred with the corresponding bolt-holes of the end-door hinges and with the end-door fastening-bolt.

(*c*) That planks which are twisted or tapered in width are not suitable for end-door planks.

The wagon has now been erected, and requires wheels, bearings, axle-boxes, bearing-springs, buffer and draw-gear fitting, and, finally, painting.

CHAPTER IV

WAGON PARTS

CALCULATION of dimensions of wagon parts—Description and function of wagon parts—Brake function—Buffer function—Continuous draw-gear function

CALCULATION OF DIMENSIONS OF WAGON PARTS

Length of the Sole-bar

1. Measure the length between the outside faces of both head-stocks, i.e. the overall length of the wagon-frame.

2. Deduct from this measurement the thicknesses of both head-stocks.

3. The remainder is the shoulder-length of the sole-bar.

N.B. For tenon-length of the sole-bar, add 3 in. to the shoulder-length. The remainder (No. 3) for a steel sole-bar represents the length of the sole-bar to inside the web of the head-stock channel.

EXAMPLE—

		Wood	Steel
Length of wagon-frame over head-stocks	=	16 ft. 6 in.	16 ft 6 in.
Deduct thickness of 2 head-stocks	=	10 in.	$\frac{7}{8}$ in.
Shoulder-length of sole-bar	=	15 ft 8 in.	16 ft $5\frac{1}{8}$ in.

Length of the Middle-bearer and Cross-bearer

1. Deduct axle-box centres from wheel-journal centres. The remainder is the width between the outside faces of the axle-guards.

2. For cross-bearers and middle-bearers of standard wagons, add to the above the depth of the cranks of two axle-guards.

EXAMPLE (Wood, 1887 Specification)—

Wheel-journal centres	=	6 ft 6 in.
Deduct axle-box centres	=	5 in.
Shoulder-length of middle-bearer	=	6 ft 1 in.

EXAMPLE (Steel or standard Wood)—

Wheel-journal centres	=	6 ft 6 in.
Deduct axle-box centres	=	5 in.
Remainder	=	6 ft 1 in.
Add depth of cranks of 2 axle-guards	=	2 in.
Cross-bearer and standard middle-bearer length	=	6 ft 3 in.

Length of the Middle-longitude

1. Add together—

(*a*) Thickness of two head-stocks.
(*b*) Thickness of two middle- or cross-bearers.
(*c*) Shoulder-length of two end-longitudes.

2. Deduct the total from the length of wagon over head-stocks.
3. Remainder is the shoulder- or web-joint length of the middle-longitude.

EXAMPLE (Standard wood)—

Add 2 Head-stock thicknesses	=	10 in.
2 Middle-bearer thicknesses	=	10 in.
2 End-longitude shoulder-lengths	=	10 ft 9 in.
Total	=	12 ft 5 in.
Length of wagon over head-stocks	=	16 ft 6 in.
Deduct previous total	=	12 ft 5 in.
Shoulder-length of middle-longitude	=	4 ft 1 in.

EXAMPLE (Steel, standard, 13 ton), Dec., 1944—

Add 2 Head-stock web thicknesses	=	$\frac{7}{8}$ in.
2 Cross-bearer web thicknesses	=	$\frac{7}{8}$ in.
2 End-longitude butt-joint lengths	=	11 ft $8\frac{1}{8}$ in.
Total	=	11 ft $9\frac{7}{8}$ in.
Length of wagon over head-stocks	=	16 ft 6 in.
Deduct previous total	=	11 ft $9\frac{7}{8}$ in.
Middle-longitude web butt-joint length	=	4 ft $8\frac{1}{8}$ in.

Length of Diagonals

METHOD I. When the wagon-frame has been erected and squared, templates are prepared to fit the position which the diagonal will occupy in the wagon-frame. (This method is fully described in Chapter X.)

METHOD II. The length and shape of diagonal joints for a wood or steel frame can be obtained from a full-scale drawing of a quarter-section of the frame. (See Figs. 14 and 15.)

WOOD FRAME

1. Draw a line 7 ft long, which represents the inside face of the sole-bar.
2. Parallel to this line, draw the longitudinal centre-line of the wagon-frame (the distance between these two lines, for a standard wagon, would be 3 ft $1\frac{1}{2}$ in.).

3. Draw a line joining one end of the parallel lines, making sure that the angles contained are 90°. This line will then represent the inside face of the middle-bearer.

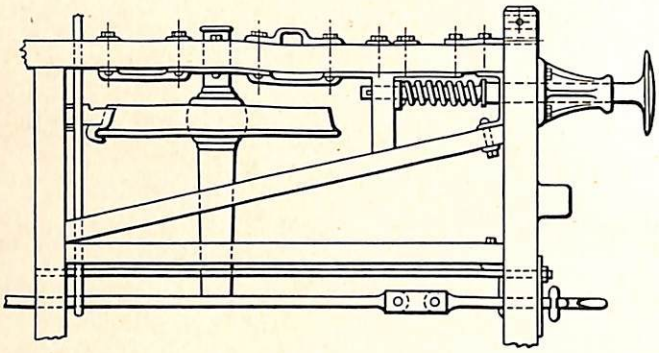


FIG. 14. QUARTER-SECTION OF STANDARD WAGON-FRAME

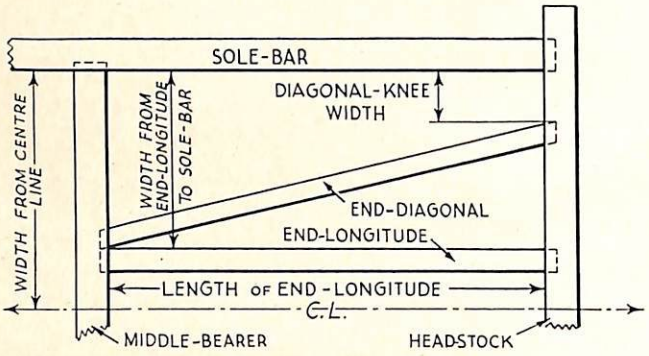


FIG. 15. METHOD OF OBTAINING LENGTH AND BEVELS OF DIAGONAL

4. From this line measure, and mark on the parallel lines, the shoulder-length of the end-longitude.

5. Draw a line joining these two marks. This line will then represent the inside face of the head-stock.

N.B. The rectangle thus formed must be tested with the trammel and any divergence rectified.

6. Measuring from the centre longitudinal line, mark on the middle-bearer line half the width between the end-longitudes and also the thicknesses of the end-longitude and diagonal (for a standard wagon the measurements would be 9½ in. and 1 ft 1 in.).

7. Measuring from the sole-bar line, mark on the head-stock

line the width of the diagonal-knee and the thickness of the diagonal (standard wagon, 8 in. and 11½ in.).

8. Draw lines joining these two sets of marks.

9. Measuring from the head-stock and middle-bearer lines, mark the length of tenons, and draw lines parallel to these lines.

10. The shape of the tenons can now be obtained by marking at the long side of the shoulder a short line at 90° to the head-stock and middle-bearer line.

The outline of the top face of the diagonal and its exact position in the wagon-frame is now completed.

N.B. When marking the template from the drawing, the template should be made $\frac{1}{16}$ in. longer than the drawing, in order to allow for the contraction of the new timber.

Steel Frame

The same principles apply to steel-frame wagons.

1. The sole-bar line.
2. The longitudinal centre-line.
3. The cross-bearer line.
4. The head-stock line, which represents the inside face of the channel-web. It is also necessary with steel-frame wagons to draw a line representing the inside edge of the channel-flange.
5. The cross-bearer line, with the position of the diagonal and middle-bearer jointing angle-iron marked.
6. Head-stock line, with the width of the diagonal-knee from the sole-bar and the thickness of the diagonal web (standard 8⅜ in.) marked.
7. These marks are now joined.

N.B. The line on the longitude side of the diagonal will cut through the line representing the inside edge of the top flange.

The length and shape of the diagonal can now be obtained from the drawing.

N.B.

(1) Allow $\frac{1}{16}$ in. extra in length to the drawing. This compensates for the tightening of riveted joints.

(2) If the diagonal joint is electrically welded, care should be taken that the joint is accurate in every respect.

Length of End-longitude

1. Add (*a*) the length of middle-longitude.
   (*b*) the thickness of 2 head-stocks.
   (*c*) the thickness of 2 middle-bearers.

2. Deduct the above total from the length of the wagon over head-stocks.

3. The remainder is the shoulder-length of two end-longitudes. Thus half of this measurement is the shoulder-length of one end-longitude.

EXAMPLE—

Add Length of middle-longitude	=	4 ft 1 in.
Thickness of 2 head-stocks	=	10 in.
Thickness of 2 middle-bearers	=	10 in.
Total	=	5 ft 9 in.
Length of wagon over head-stocks	=	16 ft 6 in.
Deduct previous total	=	5 ft 9 in.
Shoulder-length of 2 end-longitudes	=	10 ft 9 in.
Shoulder-length of 1 end-longitude	=	5 ft 4½ in.

Side-rails. The length of a side-rail is the same as the length of the wagon over head-stocks.

The thickness of the side-rails and the size of the rebate are obtained as follows—

1. Deduct the width of the wagon-frame to the outside faces of the sole-bars from the width of the wagon-body to the outside faces of the side-planks.

2. The measurement obtained is the thickness of the two side-rails.

3. If the thickness is more than 4 in., wood packings must be fitted to make the required thickness.

4. If the thickness is less than 4 in., the side-rail is rebated (shaped) to obtain the required thickness.

EXAMPLE (for rebating)—

Width to outside faces of side-planks	=	7 ft 6 in.
Deduct width to outside faces of sole-bars	=	6 ft 11 in.
Thickness of side-rails 2	=	7 in.
Thickness of side-rail 1	=	3½ in.

Thus, to fit a side-rail 4 in. thick, it would be necessary to cut a rebate 2½ in. from the top face and ½ in. deep.

EXAMPLE (for packing)—

Width to outside faces of side-planks	=	8 ft 0 in.
Deduct width to outside faces of sole-bars	=	7 ft 1 in.
Thickness of 2 side-rails required	=	11 in.
Thickness of 1 side-rail required	=	5½ in.

Thus a packing 1½ in. thick would be required.

N.B. To fit a side-rail 4 in. thick, the width of the wagon can be obtained by—

(1) Measuring the length of the fast-end planks and adding the thickness of both sides of the wagon.

(2) Measuring the length of the end-door planks, and adding $\frac{1}{2}$ in. clearance gap and the thickness of side-planks.

Length of End-stanchion. Deduct $\frac{1}{2}$ in. from the height of the fast end of the wagon; this height to be measured from the bottom face of the head-stock to the top edge of the top end-plank.

Length of Floor-plank. Deduct the thickness of two side-rails from the width of the wagon-body; this width to be measured between the outside faces of the side-planks.

EXAMPLE—

Width between outside faces of side-planks	=	8 ft 0 in.
Deduct thickness of two side-rails	=	8 in.
Length of floor-plank	=	7 ft 4 in.

Length of Side-plank. The length of side-planks is the length of the wagon between the outside faces of the head-stocks.

Length of End-plank. The length of end-planks can be obtained by either of two methods—

(*a*) Measure the width of the wagon between the inside faces of the side-planks.

(*b*) Measure the width of the wagon to the outside faces of the side- or end-knees.

N.B. In the case of end-door planks, $\frac{1}{2}$ in. must be deducted from the length obtained above for working clearance.

Length of Quarter-planks

1. Add $\frac{1}{2}$ in. clearance to the length of the side-door.
2. Deduct the total from the overall length of the wagon.
3. Divide the remainder by 2. This gives the length of the quarter-plank to side-door bevel.
4. Add $\frac{1}{2}$ in. to allow for the shape of the side-door bevel.

EXAMPLE—

Overall length of the wagon	=	16 ft 6 in.
Deduct length of side-door plus $\frac{1}{2}$ in. clearance	=	4 ft 1 in.
Remainder	=	12 ft 5 in.
Divide remainder by 2	=	6 ft 2½ in.
Add $\frac{1}{2}$ in. for side-door bevel	=	6 ft 3 in.

Thus—

(1) The length of the quarter-plank inside face	=	6 ft 3 in.
(2) The length of the quarter-plank outside face	=	6 ft 2½ in.

Length of Side-door Plank. The length of a side-door plank is the length of the side-door opening, less $\frac{1}{2}$ in. allowed for clearance.

To calculate the length—

1. Measure the overall length of the wagon.
2. Deduct the lengths of the left and right quarter-planks.
3. The remainder is the outside face width of the side-door opening.
4. Deduct $\frac{1}{2}$ in., which gives the length of the outside face of the side-door plank.

N.B. Side-door plank ends are cut to a bevel of $\frac{1}{2}$ in.

Lengths of Wagon-frame Tie-rods

LONGITUDINAL TIE-ROD 1 IN. DIAMETER

Find the overall length between the draw-bar face-plates and add the thickness of two 1 in. nuts.

TO CALCULATE—

1. Measure the shoulder-length of the sole-bar.
2. Add to the above measurements the thickness of
   (*a*) Two head-stocks.
   (*b*) Two draw-bar face-plates.
   (*c*) Two 1 in. nuts.

EXAMPLE (1907—10 ton)—

Shoulder-length of sole-bar	=	14 ft 1 in.
Add thickness of 2 head-stocks	=	11 in.
Add thickness of 2 draw-bar plates	=	$1\frac{1}{4}$ in.
Add thickness of 1 in. nuts	=	2 in.
Total length of longitudinal tie-rod	=	15 ft $3\frac{1}{4}$ in.

CENTRE CROSS-ROD $\frac{7}{8}$ IN. DIAMETER

Find the overall width of the wagon between the outside faces of the sole-bars, and add two $\frac{1}{4}$ in. plate-washers and two $\frac{7}{8}$ in. nuts.

SIDE-RAIL CROSS-ROD $\frac{7}{8}$ IN. DIAMETER

1. Find the shoulder-length of the middle-bearer.
2. Add to this

(*a*) The thickness of two sole-bars.
(*b*) The thickness of two side-rails (excluding rebate).
(*c*) The thickness of two diagonal body-braces.
(*d*) The thickness of two $\frac{7}{8}$ in. nuts.

EXAMPLE (1907—10 ton)—

Shoulder-length of middle-bearer	=	6 ft 1 in.
Add the thickness of 2 sole-bars	=	10 in.
Add the thickness of 2 side-rails (ex-rebate)	=	7 in.
Add the thickness of 2 side body-braces	=	$\frac{3}{4}$ in.
Add the thickness of 2 $\frac{7}{8}$ in. nuts	=	$1\frac{3}{4}$ in.
Total length of side-rail cross-rod	=	7 ft $8\frac{1}{2}$ in.

N.B.

1. For a wagon with spaced side-rails and packings, add the thickness of two packings and the full thickness of two side-rails in place of item (*b*) above.

2. For standard specification wagons, add 2 in. to item 1 above, this being the increase in the width of the wagon-frame.

QUARTER TIE-RODS 1 IN. DIAMETER

1. Measure the shoulder-length of the end-longitude.
2. Add to this

(*a*) Thickness of a head-stock.
(*b*) Thickness of a middle-bearer.
(*c*) Thickness of end-stanchion and washer-plate.
(*d*) Thickness of plate-washer.
(*e*) Thickness of two nuts.

EXAMPLE (1907—10 ton)—

Shoulder-length of end-longitude	=	4 ft 7 in.
Add thickness of head-stock	=	$5\frac{1}{2}$ in.
Add thickness of middle-bearer	=	5 in.
Add thickness of end-stanchion and washer-plate	=	$4\frac{7}{8}$ in.
Add thickness of washer-plate at middle-bearer	=	$\frac{3}{8}$ in.
Add thickness of 2 nuts	=	2 in.
Total length of tie-rod	=	6 ft $0\frac{3}{4}$ in.

END-DOOR QUARTER TIE-ROD

As above, with the exception of item (*c*), for which substitute end-door sill-stop $\frac{3}{4}$ in. thick in place of end-stanchion and plate. This will make the tie-rod length 5 ft $8\frac{1}{8}$ in.

Length of Intermediate Draw-bar

LENGTH OF ONE INTERMEDIATE DRAW-BAR

1. Mark the position of the draw-bar cradle on the middle-longitude (the inside length must be marked) and, measuring from the cradle end, mark the length of the spring, washer, and nut.

2. Mark on the end-longitude the position of the buffer-spring buckle intermediate bar pin-hole centre.

3. The distance between these two points is the length of the intermediate bar to pin-hole centres.

Lengths of Two Intermediate Draw-bars

This example is taken previous to the erection of the wagon-frame, and assuming that the buffer-spring buckle and the diameters of the pin-holes comply with R.C.H. Regulations.

1. The distance from the inside face of the head-stock to the centre of the draw-bar hook pin-hole is $9\frac{1}{8}$ in., and to the centres of pin-holes in buffer-spring buckles is 1 ft $1\frac{3}{4}$ in.
2. Add these two measurements, the total being 1 ft $10\frac{7}{8}$ in.
3. Double this total, which will then be 3 ft $9\frac{3}{4}$ in.
4. Measure the length between the ends of the draw-bar cradle 2 ft 0 in. and add this to the previous total, which will now be 5 ft $9\frac{3}{4}$ in.
5. Deduct this total from the shoulder-length of the sole-bar.
6. Add to the remainder the length and thickness of the spring, washers, nuts, and position of cotter-holes.
7. The total thus obtained is the length of two intermediate bars.

Example (1911 Specification)—

Distance from inside face of head-stock to intermediate draw-bar pin-hole of the buffer-spring buckle	=	1 ft $10\frac{7}{8}$ in.
Double this figure	=	3 ft $9\frac{3}{4}$ in.
Add the length of cradle between ends (2 ft)	=	5 ft $9\frac{3}{4}$ in.
Shoulder-length of sole-bar	=	15 ft 1 in.
Deduct previous total	=	5 ft $9\frac{3}{4}$ in.
Remainder	=	9 ft $3\frac{1}{4}$ in.
Add to remainder		
Length of draw-bar spring under compression	=	$7\frac{1}{16}$ in.
Thickness of draw-bar rubber spring and plate	=	$2\frac{15}{16}$ in.
Thickness of 2 washers and nuts	=	6 in.
Measurements between nuts and centres of cotters	=	$\frac{1}{2}$ in.
Thickness of draw-bar spring friction-plate	=	$\frac{1}{4}$ in.
Length of 2 intermediate bars	=	10 ft $7\frac{1}{4}$ in.
Length of 1 intermediate bar	=	5 ft $3\frac{5}{8}$ in.

Length of Intermediate Bars, Articulated Draw-gear Standard Specifications

1. Add Length of two draw-bar hooks	=	2 ft $6\frac{1}{2}$ in.
Centres of connecting-links	=	10 in.
Length of cradle between ends	=	2 ft 0 in.
Total	=	5 ft $4\frac{1}{2}$ in.

2. Length of wagon-frame over face-plates	=	16 ft $7\frac{1}{2}$ in.
Deduct previous total	=	5 ft $4\frac{1}{2}$ in.
Remainder	=	11 ft 3 in.
3. Add Length of draw-bar spring under initial compression	=	1 ft $0\frac{1}{8}$ in.
Thickness of rubber spring under initial compression	=	$1\frac{3}{8}$ in.
Thickness of washers and nuts	=	6 in.
Measurements between nuts and centres of cotters	=	$\frac{1}{2}$ in.
Length of 2 intermediate bars	=	12 ft 11 in.
Length of 1 intermediate bar	=	6 ft $5\frac{1}{2}$ in.

DESCRIPTION AND FUNCTION OF WAGON PARTS

Component	Position	Function
	Wagon-frame (Figs. 7, 9)	
Sole-bars.	Sides of the frame.	These components, when soundly constructed, constitute a complete wagon-frame. They embody all the strength and rigidity necessary to support, and withstand all the shocks which the vehicle will receive during its normal working life.
Head-stocks.	Ends of the frame.	
Middle-bearers.	Middle of the frame.	
Middle-longitudes.	Between the middle-bearers.	
End-longitudes.	Between the head-stocks and the middle-bearers.	
Diagonals.	Secured to the sole-bars.	
Side-rails.		
	Wagon-floor (Fig. 13)	
Floor, knee-sill saddle, bottom-door, hopper-plates or planks.	Covering the wagon-frame.	These components constitute a wagon-floor, the function of which is to support the load.
	Wagon-body (Fig. 13)	
End-stanchions.	End of the body.	These components have a common function, i.e. to contain the load.
End-plates or -planks.	Side of the body.	
Side-plates or -planks.		
	Wagon-doors (Fig. 13)	
	Fixed to the side, end, and floor.	Facilities to load or unload.
	Carriage	
Wheels and axles.	The determined wheel-base centres.	The medium of movement.
Axle-boxes.	Secured to the wheels, axles, and journals.	(*a*) Seating for anti-friction bearnigs. (*b*) Seating for side bearing-springs. (*c*) Seating for axle-guards. (*d*) Seating for oil-pads. (*e*) Reservoir for the lubricating-oil.

Component	Position	Function
Metal bearings.	On the wheel-journals and in the axle-boxes.	To assist movement with a minimum of friction.
Side bearing-springs.	On the axle-boxes at the determined wheel-base centre.	To impart to the vehicle constant and continuous vertical elasticity.
Bearing-spring shoes.	Fixed on the sole-bar.	Shoes for the side-spring.
Bearing-spring stops.	Secured to the under-side of the sole-bars immediately above the wheel-base centres.	The limitation of lateral side-spring movement.
Dust-shields and under-caps.	Contained in the axle-boxes.	To prevent dirt entering into the axle-box.
Oil-pads.	Contained in the axle-boxes.	To facilitate the lubrication of the journals.
Axle-guards and bridles.	Fixed on the sole-bar centred at the wheel-base.	To secure the wheels and axle-boxes in position on the wagon.
	Brakework (Fig. 18)	
Vee-irons.	Fitted to the sole-bar.	Brackets to support the spindle.
Spindle.	Fitted through the vee-irons.	To transmit the leverage to the push-rods.
Lever.	Fixed to the spindle.	The initial stage of applying the brake.
Guard, or guide.	Fitted to the sole-bar.	To limit and guide the lever.
Vee-iron space-ferrule.	Fixed between the vee-irons.	To prevent closing of the vee-irons when the lever is fixed in position.
Bracket.	Fixed on the middle-bearer.	To support and allow face movement to the brake-blocks.
Hanger-links.	Fixed to the bracket.	
Push-rods.	Fitted to the blocks and spindle	To act as connecting-rods between the brake-blocks and spindle.
Blocks.	Fixed to the push-rods and hanger-links	Friction on the wheels, thus preventing movement.
Centre safety-loop.	Fitted to the push-rods.	To prevent push-rods fouling the rail-track should they become loose.
End safety-loop.	Fitted to the middle-bearer.	

N.B. The brake function is explained in its entirety on p. 53.

Buffer-units

1. 1887 Specification Buffer (Fig. 7)

Guide.	Fitted to the head-stock.	Guide and limit the buffer-ram stroke.
Ram.	Fixed in the guide.	Receive and transmit the buffer-impact to the buffer-spring.

Component	Position	Function
Buffer-shoe and cotter.	Fitted to the buffer-ram.	(*a*) Slide for the buffing-spring ends. (*b*) Secure the ram in the correct position.
Laminated 14-plate spring.	Fitted at each end of the frame.	(*a*) Elastic absorption of the buffer-impact. (*b*) Distribution over the frame of the pulling and buffing strain.
Spring guide-plates.	Fitted to the end-longitudes.	(*a*) Prevent buffing-spring's lateral movement when resisting buffer-impact. (*b*) Slide for the buffer-spring movement.
Diagonal-wear plates.	Fitted to the diagonals.	Slide for the buffer-spring.
Spring rear check-block.	Fitted to the end-longitudes.	(*a*) Maintain the initial compression of the buffer-spring. (*b*) Facilitate the fitting and removal of the buffer-spring.

2. Self-contained Buffer (Fig. 8)

Case and plate.	Fitted to the head-stock.	(*a*) Contain the buffer-spring. (*b*) Guide and limit the buffer-ram stroke.
Ram and washers.	Fixed in buffer-case.	Receive and transmit buffer-impact to buffer-spring.
Spring (helical or volute).	Fixed in buffer-case.	Elastic absorption of the buffer-impact.

3. Standard Buffer (Figs. 9 and 11)

Guide.	Fitted to head-stock.	Guide and limit the buffer-ram stroke.
Ram.	Fixed in the buffer-guide.	Receive and transmit the buffer-impact to the buffer-spring.
Ram-cotter.	Fitted to the buffer-ram.	Secure the buffer-ram in position.
Washers.	Fitted to the buffer-ram.	Act as cushions for the buffer-springs.
Helical spring.	Fitted to the buffer-ram.	Elastic absorption of buffer-impact.
Trimmer-knee.	Fitted to the sole-bar and diagonal.	Checking and distributing the buffer-impact over the wagon-frame.

N.B. A full description of the buffer function will be found on p. 54.

Draw-gear

1. 1911 Specification (Fig. 7)

Component	Position	Function
Couplings.	Fitted to the draw-hook.	To chain wagons together.
Draw-hook and pins.	Fitted to the buffer-spring buckle.	(*a*) Hook for couplings-links. (*b*) Medium of transmitting pulling energy to the buffer-spring.
Buffer-spring buckle.	Fixed in the centre of the buffer-spring.	(*a*) Means of utilizing the elasticity of the buffer-spring. (*b*) An integral part of the buffer-spring.
Intermediate draw-bar.	Fitted to the spring buckle.	(*a*) Continuation of draw-hook and spring buckle. (*b*) Transmit the pulling-strain to the spring.
Cradle.	Between the middle-longitudes at the approximate centre of wagon-frame.	A bridge between the intermediate draw-bars.
Volute and rubber springs.	Fitted to the intermediate draw-bars.	Elastic absorption of the pulling-strain applied to the draw-bars.
Washers.	Fitted to the intermediate draw-bars and springs.	Cushions for springs.
Spring-stop.	Fitted to the intermediate draw-bars.	Limitation of the compression of the draw-bar spring.

2. Standard Specification (Figs. 9 and 11)

Couplings.	Fitted to the draw-hook.	To chain wagons together.
Draw-hooks. Connecting links, pins, and intermediate draw-bars.	Longitudinal centre of frame.	Medium of transmitting pulling-strain to the draw-bar cradle.
Cradle.	Between the middle-longitudes.	Bridge between the intermediate draw-bars.
Rubbers or helical draw-springs.	Fitted to intermediate draw-bars.	To give elastic resistance to pulling-strain.
Helical-spring stop.	Fixed inside the helical draw-spring.	To limit the compression of the helical spring.
Washers.	Fitted to the intermediate draw-bars.	To act as cushions for the spring.
Cradle-carriers.	Fitted to the middle-longitudes.	Support for the cradle.
Safety-pin.	Fitted to the draw-hook.	Safety-device in the event of the draw-hook fracturing.

N.B. A complete explanation of the principles of continuous draw-gear will be found on p. 54.

Iron and Steel Components

1. WAGON-FRAME (Figs. 7–9 and 13)

COMPONENT	POSITION	FUNCTION
Diagonal-knee.	Fitted to sole-bar, head-stock, and diagonal.	To brace and strengthen the head-stock at the point of buffer-impact.
Longitudinal-knee.	Fitted to head-stock and end-longitude.	To brace the head-stock when subjected to pulling-strain.
Rods, strap-bolts, bolts, and rivets.		(*a*) To fasten together various wagon parts. (*b*) To act as cramps.

2. WAGON-BODY (Fig. 13)

End-stanchions.	Fitted to the fast end of the wagon.	Vertical support for the fast end of the wagon.
Side-knees and washer-strap.	Fitted to the middle-bearers and the body.	Vertical support for the sides of the wagon.
End-knees and washer-strap.	Fitted to the head-stock and the body.	Vertical side support at the end-door end of the wagon.
Corner-plates, knees, and washer-straps.	Fitted to the fast-end corners.	To fasten the sides and ends together.
Diagonal body-braces.	Fitted to the wagon sides.	To prevent the wagon body moving from a square position.
Cappings.	Fitted to the top of wagon sides and ends.	To prevent damage to the top side-and-end planks.
Capping-clip.	Fitted to the top side and end-plank.	To secure the cappings in position.

3. BOTTOM-DOOR (Fig. 13)

Saddle-bands.	Fitted to the middle-longitudes.	Brackets for the bottom-door roller-bars.
Roller-bars.	Fixed through the saddle-bands and hinges.	Pivots for the bottom-door hinges.
Hinges and straps.	Fitted to the bottom door-planks and threaded on the roller-bar.	Hinges for the bottom-door.
Monkey-tail.	Fitted to the sole-bar.	Lever to lock or unlock the bottom-doors.
Monkey-tail fastener.	Fitted to the sole-bar.	Sleeve to receive the monkey-tail.
Monkey-tail peg and chain.	Fitted to the sole-bar.	Pin to lock the monkey-tail in the sleeve.

4. END-DOOR (Figs. 13 and 20)

COMPONENT	POSITION	FUNCTION
Roller-bar, or end-door tie rod.	Threaded through the end-knees.	Pivot for the hinges.
Roller-bar stop.	Fitted to the side of the wagon.	To prevent the roller-bar moving out of position.
Roller-bar cotter.	Fixed through the roller-bar.	To lock the roller-bar in position.
Hinges and washer-straps.	Fitted to the end-door planks and threaded on the roller-bar.	Hinge for the door.
Fastener-bar.	Fitted to the end-door.	To fasten the end-door in position.
Studs or fastener bolts and pins.	Fitted to the quarter-planks.	To secure or release the end-door.
Sill-plate.	Fitted to the end-sill.	To protect the end-sill during unloading.
Sill-stop. Plate, or lip buffer guide.	Fitted to the head-stock and end-sill.	To secure the end-sill in position.

5. SIDE-DOOR (Fig. 13)

Type I		
Hinges and feet.	Fitted to the side-door and side-rail.	To hinge the side-door.
Fasteners.	Fitted to the side-planks.	To lock or unlock the door.
Spring.	Fixed on the sole-bar.	(*a*) To provide spring resistance to the weight of the falling side-doors. (*b*) To prevent damage to doors and brake-work.
Striking-plate.	Fixed on the side-door.	To prevent damage to the side-door as the falling door contacts spring.
Sill-plate.	Fitted to the side-rail.	To prevent the wear of the side-rail during unloading.
Type II		
Eye-bolts.	Fitted to the side-door.	Bracket on which the door can swing.
Swing-bar.	Threaded through the eye-bolts.	Pivot for the hinges.
Hinges and strap.	Fitted to the door planks and threaded on the swing-bar.	Hinges for the door.
Cotters or fasteners.	Fitted to the side.	See *Type I*.

BRAKE FUNCTION

The application of the brake in the first stage is by pressure of the lever (which has a leverage ratio of 22 : 1) down the brake-guard (or guide). This pressure is then transmitted through the spindle and the push-rods to the brake-blocks, which are pressed

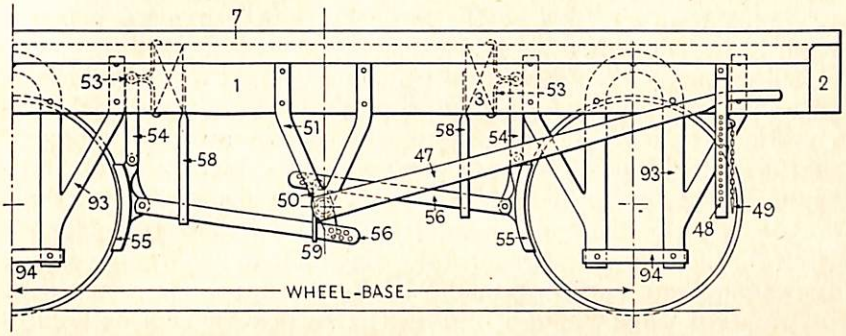


FIG. 16. BRAKEWORK

1. Sole-bar.
2. Head-stock.
3. Middle-bearers.
7. Side-rail.
47. Brake-lever.
48. Brake-guard.
49. Brake-guard peg and chain.
50. Brake-spindle.
51. Brake vee-irons.
53. Brake-bracket.
54. Brake-block hanger-links.
55. Brake-block.
56. Brake push-rods.
58. Brake-block end-carriers.
59. Brake centre safety-loop.
93. Axle-guard.
94. Axle-guard bridles.

against the wheel-tire, thus creating an instant friction. This enables the motion of the vehicle to be arrested or released at the will of the operator.

The lever is secured in the "on" position by a peg and chain, the peg being inserted into the necessary holes provided in the

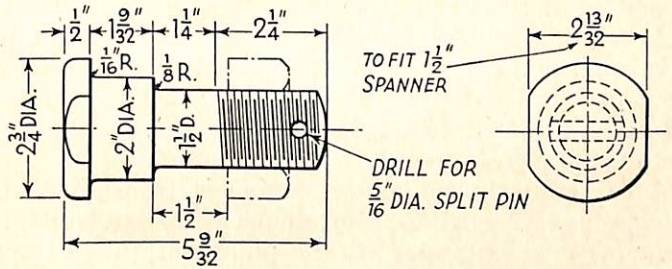


FIG. 17. MORTON BRAKE-FULCRUM BOLT

brake-guard. If the lever is not pinned in this manner it should be positioned in the "off" position, i.e. at rest, in the bracket incorporated in the top of the brake-guard.

BUFFER FUNCTION

The buffer-impact pushes the ram (which is controlled by the buffer-guide in the length it can travel), and the impetus is resisted and partially absorbed by the buffer-spring, then by the rear check-blocks, and finally by the whole wagon-frame. Thus it is seen that the force of the buffer-impact ultimately expends itself in the movement of the vehicle.

The principle of buffer-impact and movement of the vehicle is just the same in both standard wagons and those fitted with self-contained buffers, although laminated springs are not employed in the latter case. The buffer-impact is received on each individual buffer-spring (helical or volute), being checked in standard wagons by the trimmer-knees, from which the energy expends itself through the sole-bars and the diagonals to the whole vehicle. In wagons with self-contained buffers, the impact is received as in standard wagon design, but as the springs (helical or volute) are contained within the buffer-casing, the impact is checked directly by the head-stock, which results, as in other methods, in the movement of the whole vehicle.

CONTINUOUS DRAW-GEAR FUNCTION

The initial pulling-strain is taken in the first stage of movement by the leading draw-gear components: coupling, draw-bar hook and pin, through the buffer-spring buckle to the buffer-spring (during this stage some of the pulling-strain is dispersed to the buffer-shoes, diagonal-knees, and wagon-frame). The buffer-spring buckle is connected by a pin to the intermediate draw-bar, which transmits the pulling-strain to the draw-bar steel spring and cradle.

At the trailing-end of the wagon the continuity of pulling-strain is applied from the cradle to the draw-bar rubber spring, intermediate draw-bar, pin, buffer-spring buckle, and the rear check-blocks (or, if the check-blocks are short, by the draw-bar hook), to the wagon-frame.

Thus the pulling-strain of the engine is transmitted by the leading coupling, through the continuous draw-gear to the trailing draw-bar hook which transmits the pulling strain to the wagon frame where it is absorbed and ultimately dissipated in movement of the wagon.

N.B. Whether the pulling-strain of the locomotive is applied through the laminated buffer-spring unit, with its various components, or by continuous articulated draw-gear components, the

fundamental principles remain the same. With a steel frame wagon, fitted with independent draw-bars, the leading draw-hook transmits the pulling-strain to the steel frame, causing movement of the wagon within the length of the following coupling attached to the following wagon, which takes the pulling-strain at its leading end.

CHAPTER V

WAGON REPAIRING

INTRODUCTORY notes—Repairing of wagon-frame members (stripping, marking-out, and fitting)—Patch-plating of wood-framed wagons (R.C.H. Regulations)—Generally-repaired wagons—Hopper self-emptying floor (marking-out and assembly)

INTRODUCTORY NOTES

The Repairing of Private Owners' Wagons. Private owners' new railway wagons are built to the specifications and designs approved by the Railway Clearing House, and when completed are subjected to inspection by representatives of the railway company on whose lines the vehicle will run. This procedure dates from 1885, when an accident at Pennistone, which caused much damage and loss of life, was found to be the result of the breaking of a wheel-axle. Since then the railway companies have inspected all new and repaired wagons, including reconstructs, converts, rebuilds, and generally-repaired rolling-stock.

Maintenance. Privately-owned wagons are of numerous types, but the majority are wooden wagons, i.e. oak frames, deal-wood bodies, and spruce-wood floors; the remainder being steel wagon-frames with wooden bodies and floors, and a number of all-steel mineral wagons. In addition to these, it should be noted that there are a large number of tank wagons.

When a wagon is not safe to carry a load, it is termed a cripple. The usual causes of this are—

(*a*) Depreciation of timbers due to wear and tear.
(*b*) Corrosion and failure of steel components.
(*c*) Excessive speed when shunting.
(*d*) Derailment or damage whilst in service.
(*e*) Hot bearings.

The 1887 Specification and Subsequent Addenda. Wagons built to this design and specification are similar in design, but vary considerably in constructional details owing to—

1. The numerous improvements added by the R.C.H. between 1887 and 1921, in the form of constructional alterations to the original specifications.
2. The varying constructional methods practised in different privately-owned workshops; the machine plant available; the conditions under which the building and repair of wagons are

performed; and also the facilities, if any, for the training of apprentices.

3. Repairs executed by wagon repairers who in some cases had not had the opportunity of proper training.

Because of these facts, each wagon part to be renewed must be measured and specifically prepared for that particular wagon. Thus the repairing of wagons demands a detailed constructional knowledge combined with a skilled use of tools.

General Repairs. When wagons are repaired, such repairs must be carried out in conformity with the standard specification (and addenda thereto) to which they were built, except in the case of wagons built prior to 1907, which as far as practicable must be repaired in accordance with the 1907 Specifications and Addenda thereto.

The above R.C.H. Regulation is clear and concise. The important addenda added by the R.C.H. to the 1887 Specification are—

Brakework. A brake-lever must be fitted to both sides of wagons in accordance with Statutory Rules and Orders, 1931, No. 945, the leverage to be not less than 22 : 1.

Buffing- and Draw-springs. All renewals of laminated buffing-springs must be 14-plate springs to Drawing 208A, with the standard initial camber of 7 in. Where 12-plate springs are replaced by 14-plate springs, the reduction of the buffer-stroke from 6½ in. to 5 in., by fitting 11½ in. buffer-guides or by packing out the existing buffers 1½ in., will not be insisted upon, provided that in the event of a buffer-guide subsequently requiring renewal two 11½ in. buffer-guides are used.

Couplings. New and repaired couplings must be in accordance with one of the following alternatives—

1. Three links of grade A iron, B.S. Specification No. 51, welded at the side, but not at the "Gedge" flat.

2. Two solid links of steel, B.S.I. Report 24, Part 4, 1930—Specification 9, Class B, 26 to 32 tons tensile, connected with a centre link of grade A iron, welded at the side.

3. Three solid links of steel, B.S.I. Report 24, Part 4, 1930—Specification 9, Class B, 26 to 32 tons tensile.

The welding of steel coupling-links will not be permitted, and the welding of iron coupling-links must not be done at outside stations without the apparatus and workmanship having been approved by the railway companies.

The breaking-load of couplings must be not less than 60 tons.

Door-fasteners. To be renewed in accordance with 1907 Specification and Addenda.

Draw-gear. "Replace" draw-hooks, bars, links, pins, and couplings *must* be in accordance with Drawings 1044 and 1045,

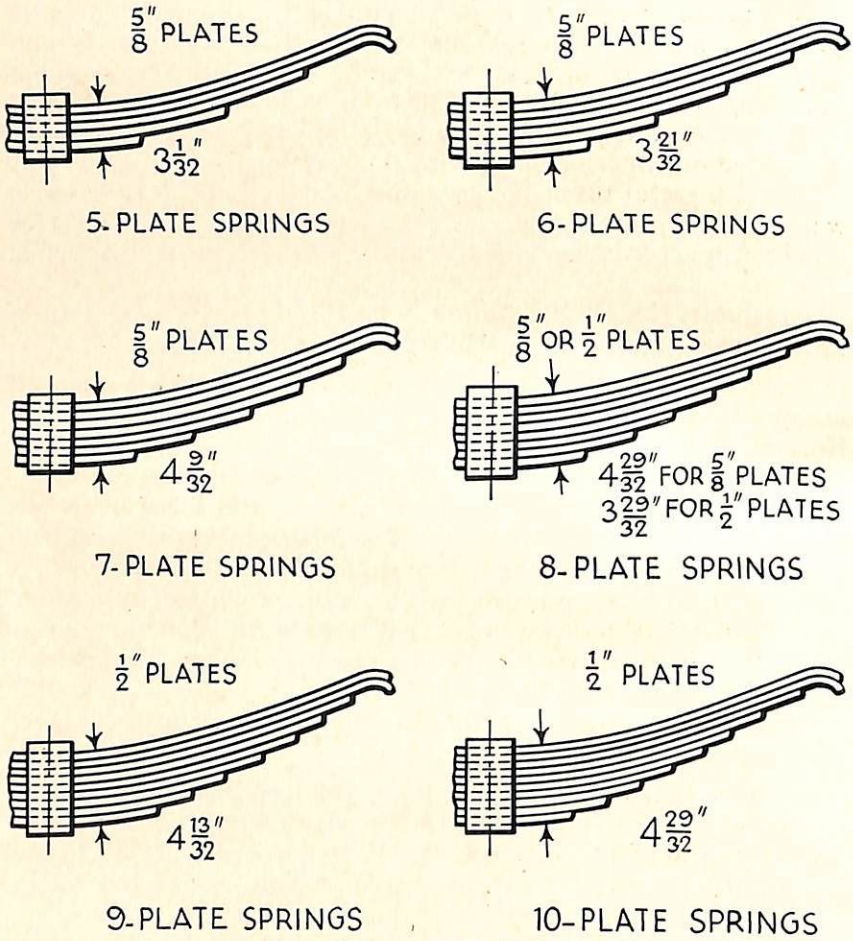


FIG. 18. LAMINATED SPRINGS

but "replace" cradles for wagons built to the 1907 or prior specifications *must* be in accordance with Drawing 18B, dated February, 1911.

Axle-guards. The crown-legs to be $3\frac{3}{4} \times \frac{3}{4}$ in.

Draw-gear. The welding of ends on any part of the draw-gear is not permitted.

Through-rods. Continuous through-rods must be fitted.

Wheels. Replaced wheels to wagons built in 1905 or later must have wrought-iron or steel centres.

Bearings. To be renewed with the deep-lugged type to Drawing No. 95.

Side-springs. Repaired bearing-springs must strictly conform in all respects, including camber, to the original design of spring now shown on Drawing No. 208A, and will be accepted as replacements provided the combined thicknesses of plates are not less than those shown in Fig. 18.

REPAIRING WAGON-FRAME MEMBERS

(Applicable to all types of wagons constructed of wood, with obvious adjustments)

Removal of the Sole-bar

1. Remove all the necessary floor-planks and clean all the dirt from the top of the frame.
2. Take out the buffer-spring blocks and the draw-bar, and release the intermediate bar.
3. Choosing the best end of the wagon, ease the head-stock at that end clear of the sole-bar tenons, and remove the buffer-spring shoes at the ends of the sole-bars.

N.B. If a wagon has the box-type of body with the corner-plates extending over the side-rail, remove the corner-plate at the end chosen for removing the head-stock.

4. Remove the side-rail, axle-guard bridles, and side spring-shoe bolts.
5. Fasten the wheels with wedges, and fit a lifting screw-jack under the centre of the sole-bar. Lift the side of the wagon until the bearing-springs can be removed.
6. Place two scrap ends of sole-bars on the top of the wheel-axles close to the wheel-boss and place edgeways on these a plank 3 in. thick, 7 in. or 8 in. wide, and a foot longer than the overall length of the wagon. Care must be taken that the top edge of the plank is so placed that it will miss all spring- and knee-bolts.
7. Lower the wagon on to the plank.

N.B. Before removing the screw-jack, check level of frame.

8. Remove all ironwork parts and ease the head-stock off the sole-bar tenons.
9. The sole-bar can now be removed.

N.B. It is advisable to place trestles to support the sole-bar when it is released from the middle-bearer tenons.

If the sole-bar is difficult to remove, use a light jack between the middle-longitude and the sole-bar.

A lever bar should be used when easing the sole-bar tenons from the head-stock, care being taken with regard to personal injury.

Removal of Middle-bearers and Middle-longitudes at the Same Time as the Sole-bar. When using the above method of removing a sole-bar, other frame-members can be removed at the same time, thus saving bolts, additional repairs, and labour. To remove the middle-bearer when removing the sole-bar—

1. The head-stock, which has been eased off the sole-bars tenons, must be eased off a further 6 in.
2. The end-pillar will also have to be eased off to allow this or, if the head-stock is at the end-door end, all knee-feet bolts will have to be removed.
3. Remove from the middle-bearer
   (*a*) Diagonal tie-rods.
   (*b*) Through-rods.
   (*c*) All ironwork parts.
4. With suitable packings, place a light screw-jack between the bearers and, at the end already opened, force the bearer off the middle-longitude tenons.
5. Remove the middle-longitudes.
6. Support the end-longitudes and diagonals at the bearer end.
7. Remove one or both middle-bearers as required.

N.B.

1. An alternative method is to remove the head-stock and end-timbers, and then the middle-bearer; if this method is used, care must be taken that the body is in a position which ensures the utmost safety.
2. An alternative method of renewing a defective sole-bar is to withdraw the wheels and substitute wood-blocks cut to the radius of the wheel-tires; the wheels must be positioned under the head-stocks. The advantage of this method is free access for the stripping and renewal of the sole-bar, but it should be noted that this method is not so practical where removing middle-longitudes and middle-bearers is concerned.

Measuring the Wagon-frame Prior to Marking the Sole-bar.

Before the new sole-bar is marked it must be examined to see if it has warped edgeways. If this is the case, the hollow edge should be marked for the top face and the round edge for the bottom face.

1. Measure the overall length of the wagon, and calculate the shoulder length of the sole-bar and check the length obtained on the fixed sole-bar.

2. On the outside face of the fixed sole-bar, measure and mark accurately the position of the transverse centre-line, measure the distance between the axle-guards' legs, obtain the centre, and mark this on the face of the sole-bar. Check the accuracy of wheel-base centres, measuring from the transverse centre-line.

N.B. The axle-guard centres are the wheel-base. In new specification wagons this is usually 9 ft 0 in., although in some 8-ton wagons it may be 8 ft 6 in.

Marking-out the New Sole-bar

1. Obtain the centre and square a line from this point; round all faces and edges of the sole-bar.

2. Mark from the centre-line

(*a*) The wheel-base—4 ft 6 in. either side.
(*b*) The tenon shoulder-length of the sole-bars—on a 15 ft wagon this will be 7 ft 1 in. either side of the centre-line.
(*c*) Brake vee-iron bolt-holes.
(*d*) Side-door bang-spring bolt-holes.
(*e*) Cross-rod holes.

3. Measure the spacing of the head-stock mortises and mark these on the sole-bar, allowing at least 1½ in. for the length of the tenons.

4. Mark the strap and diagonal-knee bolt-holes.

5. From the wheel-base centre-lines mark

(*a*) Side bearing-spring shoe-centres.
(*b*) Bearing-spring shoe bolt-holes.
(*c*) Position of side spring-stop.

6. Obtain the centre of the side-rail and place one end of a staff, approximately 7 ft 6 in. in length, on this centre-line. Mark on this staff the side-rail bolt- and rod-holes in that half of the side-rail. The staff can now be placed on the centre-line of the sole-bar and the holes marked on the new sole-bar. The other half of the side-rail is treated in the same manner.

N.B. The distance of the side-rail bolt-holes from the top of the sole-bar is found by measuring the distance from the bolt-holes to the top of the side-rail rebate. If the side-rail is not rebated, the measurement is made from the top of the side-rail and 2½ in. deducted for the thickness of the floor-planks.

7. Measure the width between the axle-guard legs (usually $9\frac{1}{8}$ in.) and

(*a*) Measure $4\frac{9}{16}$ in. either side of the wheel-base line on the new sole-bar.

(*b*) Square and mark these two lines across the inside face of the sole-bar.

(*c*) Draw a line lengthways $2\frac{1}{8}$ in. from the bottom edge of the sole-bar and 1 ft 9 in. either side of the wheel-base centre-line. This line is the centre of the bottom axle-guard bolt-holes from the bottom face of the sole-bar. (1887 Specification.)

(*d*) Place the axle-guard on the sole-bar, the axle-guard crown-legs and bottom bolt-holes being positioned by the above marks.

(*e*) Press to the bottom edge of the sole-bar a square with a blade 2 ft 0 in. long, and move the axle-guard crown-leg nearest the head-stock until it is true to the square and also $4\frac{9}{16}$ in. from the wheel-base centre-line.

(*f*) Mark and centre-pop all bolt-holes.

Rectification of Incorrect Sole-bars. The life of a wood-frame wagon is considerably lengthened by means of extensive repairs, which may sometimes consist of a complete renewal of the wagon-frame. Since many wagons of similar type (excepting railway company stock) differ in constructional details, and since also these major repairs are carried out by workman who may or may not have been taught the correct principles of wagon construction, it sometimes occurs that frame-members are fitted incorrectly.

For instance, a wagon requires a new sole-bar and, the defective member having been removed, it is found that the remaining sole-bar is 1 in. short, i.e. on a wagon 15 ft 0 in. overall the sole-bar is 14 ft 1 in. instead of 14 ft 2 in. between the tenon-shoulders. This defect can occur in two ways—

1. The sole-bar may be $\frac{1}{2}$ in. short either side of the centre-line. For this there are two remedies:

(*a*) Assuming that the head-stocks already on the wagon are 5 in. thick, these could be replaced by head-stocks of $5\frac{1}{2}$ in. thickness.

(*b*) Longitudes, diagonals, and the body of the wagon could be shortened to match the sole-bar.

2. The sole-bar may be 1 in. short on one side of the centre-line and be the correct length on the other side. In this case, the sole-bar would have to be shortened to 14 ft 0 in. and 6 in. head-stocks fitted (again assuming that the original head-stocks were

5 in. thick). This would also entail the corresponding shortening of the diagonals and end-longitudes.

N.B.

1. Where a sole-bar is less than 1 in. short, the end-timbers and the wagon-body would require shortening, and head-stocks of 6 in. thickness would then be fitted. Obviously in such circumstances the wagon would be rebuilt.

2. If the sole-bar is too long, the defect can be remedied by shortening to the correct length either side of the centre-line.

Fitting a New Sole-bar. Having prepared the sole-bar as described above—

1. Attach the bearing-spring shoes, side spring-stops, and the bottom door-fastener (if any).

2. Enter the sole-bar tenons into the mortises of the head-stock which has not been eased out of position, positioning the sole-bar with screw-jack for fitting in the wagon-frame, and secure the sole-bar to the head-stock temporarily by the fitting of a strap-bolt and nut.

3. With a screw-jack, lift the sole-bar level with the top of the frame and enter the bottom cross-rods into the relative holes.

4. Using a frame-cramp, press the sole-bar to the middle-bearer shoulders and screw up the cross-rods.

5. The head-stock, which was eased off during the removal of the defective sole-bar, can now be forced home to the sole-bar shoulders.

6. Fix and bolt on the sole-bar all necessary ironwork.

The Frame and Axle-guards

Longitudinal Squaring Axle-guards. To test the axle-guard centres on one sole-bar with the centre of the sole-bar, the following method is adopted—

1. Obtain a wooden staff approximately 12 ft 0 in. × $1\frac{1}{2}$ in. × $\frac{3}{4}$ in.

2. Put one end of the staff to the outside leg of the left-hand axle-guard and mark on the staff the point of intersection with the centre-line of sole-bar. The position of the outside leg of the right-hand axle-guard should be identical in its relation to the sole-bar centre-line.

3. Test the top and bottom of the legs for position of true squareness.

4. Check the same centres on the opposite sole-bar, since all centres of axle-guards should be identical.

Diagonal Check of Axle-guards. Assuming that the axle-guards on the sole-bars have been checked and found to be true in every respect—

1. Place the staff diagonally under the wagon-frame with one end pressed against the outside crown-leg of the left-hand axle-guard on the remaining sole-bar.
2. Mark on the staff the position of the outside crown-leg of the right-hand axle-guard fitted to the new sole-bar.
3. Test the length obtained at the top and bottom of the axle-guard legs; if there is any variation, one of the axle-guards is out of square.
4. If these axle-guards are found to be true, the opposite axle-guards can then be tested in a similar manner.

N.B. The lengths between diagonally-opposite axle-guards should strictly be exactly the same, but a variation of $\frac{1}{4}$ in. is allowed.

Racking the Wagon-frame Square. Frames and axle-guards which are not true diagonally must be adjusted to the correct position. This is known as racking the frame.

1. Loosen all frame-rods and free the wheels.
2. Place across the frame, about a foot out of square, a cramp which will force the sole-bars in opposite directions until the frame is square.
3. When satisfied with regard to the squareness obtained, screw up all the frame-rods.
4. If there is any difficulty encountered in this, examine the lengths of the diagonals. It will probably be found that one has been fitted at an incorrect length.
5. If the frame has been knocked out of square by excessive buffer-impact, use the cramp from corner to corner of the head-stocks; if difficult, *release the body* and examine the cross-rods. If these are found to be corroded they should be replaced.

The Head-stock

Stripping. This frame-member requires to be renewed more frequently than any other for the following reasons—

1. Excessive force used in shunting.
2. Weak buffer-springs unable to resist the force of impact.
3. Partly broken or decayed sole-bars and diagonals being unable to withstand the shock of the buffer-impact, which is transmitted from the buffer-guide to the head-stock.

4. The timber from which the head-stock is shaped may be cross-grained or contain large knots.

5. The head-stock may have been badly fitted owing to, e.g.—

(*a*) Mortise holes larger than the tenons.
(*b*) Loose head-stock hoops.
(*c*) Short end-timbers.

Before removing the head-stock from the frame, examine the break and, if possible, determine the cause. Perhaps this will be found to be the shortness of other frame-members, in which case it can be remedied by the fixing of suitable packing-plates.

Commence to strip the head-stock—

1. Remove buffer-rams, guides, end-pillars, knee-feet bolts, draw-bar hooks, and other sundry nuts and bolts.

2. Examine the diagonal knee-bolts before releasing the head-stock, as it sometimes occurs that these bolts are broken; if this is not noticed before the head-stock is released, the loosening of the head-stock will release the buffer-spring, thus causing much extra work.

3. If the diagonal knee-bolts are broken, take out the buffer-spring blocks and remove the buffer-shoes, when the diagonal knee-bolts can be renewed without any difficulty.

4. Unscrew the sole-bar strap-bolts.

5. The head-stock can now be forced off the frame.

Marking-out

1. Measure the length of the head-stock and, marking the centre, square a line round all faces and edges.

2. Mark the position of the head-stock hoops by measuring 2 in. from each head-stock end, and on these marks square a line round all faces.

3. Choose the top face of the head-stock, mark this "TOP," and then mark the inner face of the head-stock.

4. Mark the width of the frame, 3 ft $0\frac{1}{2}$ in. either side of the centre-line (3 ft $1\frac{1}{2}$ in. standard specification.

5. From these lines, measuring towards the ends of the head-stocks, mark the thicknesses of the sole-bars.

6. From the inside sole-bar line measure the position of the diagonal from the sole-bar (usually 6 in. spacing), and add to this the thickness of the diagonal.

7. From the head-stock centre-line, mark the position and thickness of the end-longitudes (9 in. space between).

8. Measure and mark the spacing of all tenons and under-beds.

9. Between the sole-bar position-lines mark the position of the short sole-bar strap-bolts.

10. Measuring from the head-stock centre-line, mark the buffer centres (2 ft 10¼ in.) and from the buffer centre-lines mark the centre of the buffer-guide bolt-holes, which can be obtained from the buffer-guides.

11. Centres of diagonal tie-rods can be obtained from the old head-stock or from the middle-bearer, and are usually marked 2½ in. from the top edge of the head-stock. This measurement, however, sometimes varies and, if there is any doubt, it is advisable to check by the end-pillar washer-plate in the following manner—

(*a*) Place the plate in position on the end-pillar bolts.
(*b*) Measure the distance from the bottom face of the fast-end sill to the centres of the tie-rod hole.

12. The width of the tie-rod centres is obtained by measuring the centres of end-pillars, and is marked accordingly.

13. Draw-bar mortise-holes are marked ½ in. out of centre as follows—

(*a*) Draw a line parallel to, and 6½ in. from, the top edge of the head-stock.
(*b*) Draw two lines 1⅝ in. either side of and parallel to the above line.
(*c*) Measure 1⅛ in. from the centre-line of the head-stock and draw two lines at right-angles to the above lines.
(*d*) The position of face-plate rod- and bolt-holes can be obtained from the face-plate.

N.B. If the head-stock is at the end-door end of the wagon, the centres of the end-knee bolt-holes can be obtained by measuring from the inside face of sole-bars, marking the centres obtained from the inside sole-bar line. To obtain the distance of the holes from the inside face of the head-stock—

(*a*) Place a straight lath across both sole-bars.
(*b*) Press the lath up to the sole-bar shoulders.
(*c*) Measure from the inner edge of the lath to the centre of the knee bolt-holes.
(*d*) This gives the position of the end knee-feet bolt-holes.

Fitting

1. Cramp in the wagon-frame to a width of 6 ft 1 in. between the inside faces of the sole-bars.

2. Check the lengths of the diagonals and longitudes by obtaining a straight-edged lath approximately 7 ft 0 in. long, and pressing this lath up to the sole-shoulders.

3. If the diagonals or longitudes are short:

(*a*) By $\frac{1}{4}$ in.—fit packing-plates $\frac{1}{4}$ in. thick.

(*b*) By $\frac{1}{2}$ in.—a thicker head-stock can be fitted, mortised into the sole-bar shoulders to the required depth, or otherwise new end-timbers should be fitted.

4. Each under-bed, longitude, and diagonal mortise should be measured to ensure a good fit.

N.B.

1. When marking a mortise for an under-bed on a head-stock, allow at least $\frac{1}{16}$ in. for tightening.

2. The mortise should be the same depth at the top and bottom.

3. Take care that all mortises fit the tenons, the diagonal inside-edge mortise being bevelled $\frac{5}{16}$ in.

4. If the under-bed is short, screw on a packing-plate $4\frac{1}{2} \times 3\frac{1}{2} \times \frac{1}{4}$ in.

5. Cramp the head-stock into position.

6. Bolt on all iron and woodwork parts.

The Middle-bearer

Stripping

1. Remove the necessary floor-planks and take out the buffer-rams and draw-bar hook.

2. With the aid of a buffer-spring pull, remove the spring-blocks and, releasing the tension on the intermediate bar, unscrew the nut from this bar.

3. Remove buffer-guides, end-pillars or end knee-feet bolts, strap-bolts, and rod-nuts.

4. Remove the head-stock.

5. Draw the through-rods from the bearer and remove the diagonal tie-rods.

6. Unbolt and remove one diagonal-knee and release the opposite diagonal from the diagonal-knee.

7. This releases the end-timbers with the buffer-spring still threaded between them. These end-timbers can now be pulled clear of the wheel-axle and removed.

8. Remove one axle-guard, brakework parts, side knee-feet bolts, and the side-rail cross-rod.

9. Loosen the remaining cross-rods and, with the aid of the frame-spreader, force the sole-bar off the bearer-tenons.

10. The middle-bearer is now free to be removed.

Marking

1. Mark the centre of the middle-bearer and square a line round all faces and edges.

2. Either side of the centre-line, measure 3 ft $0\frac{1}{2}$ in. and, adding $1\frac{1}{2}$ in. to each of these measurements, mark the length of the tenons.

3. Measure the spacing of the middle-bearer mortises (guided from the top face of the sole-bars) and mark these measurements in the spaces marked for tenons from the top face of the bearer.

4. Mark the centres of the brake-bracket bolt-holes (usually $6\frac{3}{4}$ in. from the shoulders of the middle-bearers).

5. Mark the centres of push-rod carrier bolt-holes.

6. Measure and mark the position of the intermediate draw-bar hole, the centre of which is 6 in. from the top edge of the middle-bearer.

7. Measure and mark the spacing between the middle-longitudes (5 in. either side of the centre-line) and the width between the end-longitudes ($4\frac{1}{2}$ in. either side of the centre-line).

8. Measure the spacing of end- and middle-longitude tenons and mark the position of the corresponding mortise-holes.

9. Mark the centres of the through rod-holes (these are obtained from the draw-bar face-plate).

10. Mark the centres of diagonal-end tie-rod holes, which are determined by the position of side-rail cross-rods, and the width of end-pillar centres, which are usually 2 ft 9 in. and $2\frac{1}{2}$ in. from the top face of the middle-bearer and the head-stock.

11. Find the centres of the side knee-feet bolts by measuring from the face of the side-sheeting to the centre of the knee-feet bolts and deducting from this measurement the distance from the face of the side-planks to the inside face of the sole-bar. The centre thus obtained is marked on the top face of the middle-bearer, measuring from the tenon shoulder-line.

Fitting

1. Check the height of the frame at the four corners; if this is unequal, pack the side-spring, or use a prop under the sole-bar at the low corner.

2. Fit the middle-bearer into the frame and cramp into position.

3. Slack off the frame-spreader, screw up the cross-rods, and fix and bolt all necessary ironwork.

4. Fit and bolt the diagonal to the fixed diagonal-knee and then fit in the end-longitude.

5. To secure the end-longitude, nail a strip of wood to the

bearer and longitude, and also to the diagonal and longitude at the approximate spacing.

6. Support the end-longitude with a screw-jack or, if a screw-jack is not available, a prop or trestle, and then thread the buffer-spring between these two end-timbers.

7. Slide the remaining longitude and diagonal on to the buffer-spring and place in position.

8. Screw up the lifting-jack until the other diagonal-knee can be bolted to the sole-bar and the diagonal, and then proceed with the fitting of the head-stock.

9. Cramp the frame in to 6 ft 1 in. between the sole-bars and check the strap-bolts for correct centres.

10. Place the head-stock on the strap-bolts and force into position by cramping.

11. Fit all necessary iron and wooden parts.

Middle Longitude

Stripping. The stripping of this frame-member can be done by any of the following three methods—

Method I

1. Choose the end of the wagon most convenient for stripping and remove the floor-planks, head-stock, end diagonals, end-longitudes, and buffer-spring.

2. Remove 3 cross-rods, 2 tie-rods, and 1 axle-guard, and withdraw the through-rods clear of the middle-bearer.

3. Remove the hanger-links and side knee-feet bolts from the middle-bearer to be eased back.

4. With the frame-spreader, open the frame sufficiently to enable the middle-bearer tenons to be freed from the sole-bar.

5. Ease the middle-bearer outwards until the middle-longitude tenons are freed from the bearer. The middle-longitudes can then be removed.

Method II

1. Remove the floor-planks.

2. Remove the cross-rods which pass through the middle-longitudes.

3. Remove the through-rods from the middle-bearer.

4. Release the tension of the draw-gear; the middle-longitudes can then be sawn through and removed.

Method III

This method is similar to that described in Method II above, except that, instead of sawing through the middle-longitudes,

extended mortises are cut diagonally to the end of the longitude-tenons. The middle-longitudes can then be removed.

N.B. It is advisable when using Methods II and III to have the assistance of a screw-jack for easing the tension off the longitude shoulders.

Marking

1. To obtain the shoulder-length, measure the distance between the middle-bearers as positioned in the sole-bars.
2. Measure the spacing of the middle-longitude mortises in the middle-bearers for tenon sizes, and mark them on the middle-longitude.
3. Measure the cross-rod holes from the inside edge of the sole-bar middle-bearer mortises and the top face of the sole-bar.
4. Find the position of the bottom-door saddle-band holes by—

(*a*) Measuring between the outer edges of the bottom door-hinges.
(*b*) Adding
  (i) The width of one saddle-band (usually $2\frac{1}{2}$ in.).
  (ii) $\frac{1}{4}$ in. for working clearance.
(*c*) Halve the measurement obtained.

The final measurement is marked from the centre-line of the middle-longitude.

N.B. An alternative method of marking the bottom-door saddle-band bolt-holes is to use the bottom-door saddle-band as a template, taking care that if the longitudes are equally spaced from the centre the distance of the roller-bar holes in the saddle-bands are equally spaced from the outside of the middle-longitudes.

Fitting. An alternative method of jointing the middle-longitude, which does not necessitate the opening of the frame, is as follows—

1. Saw the middle-longitude out of the frame and then mark as described for a new middle-longitude, allowing $\frac{1}{4}$ in. from the top of the tenon at one end and $\frac{1}{4}$ in. from the bottom of the tenon at the other end. This allowance is for a saw-cut.
2. Bore four deep-way bolt-holes in the middle-longitude and mark a line diagonally from the top of the tenon at one end to the bottom of the tenon at the opposite end.
3. Saw the middle-longitude down this line, thus leaving two pieces, each with two tenons.
4. Fit one piece in the middle-bearer and the other piece in the other middle-bearer; bolt together, using four deep-way bolts.

This method is the easiest and most economical, and properly fitted is equal in working efficiency to a solid middle-longitude.

N.B. To assist in fitting the longitude, use a bottle-jack placed in the centre of the bearer, about 3 in. from the top edge, and spread the bearer $\frac{1}{4}$ in. (The longitudinal rods and intermediate bars will require unscrewing to allow for the spreading of the bearer.)

The End-longitudes

Stripping

1. Remove draw-bar pins and unfasten the head-stock sufficiently to free the longitude.
2. Strip the longitude and remove.

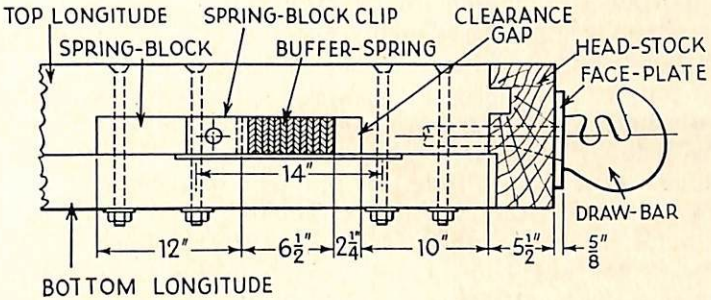


Fig. 19. Cutting Out the End-longitude

Marking (Fig. 21)

1. Measure the distance from the middle-bearer to the sole-bar shoulders and add to this $\frac{3}{16}$ in. The final measurement is the space to be cut out to accommodate the buffer-spring.

N.B. In the 1887 Specification the required space is $21\frac{1}{2}$ in.

2. The clearance between the front plate of the buffer-spring and the end-longitude, when the wagon is fitted with an 18 in. cradle and a $6\frac{1}{2}$ in. draw-spring, is $1\frac{1}{2}$ in.; but for wagons fitted with 14-plate buffer-springs, 2 ft cradle, etc., a buffer-spring clearance of $2\frac{1}{4}$ in. is required. Thus the measurements to be marked on the longitudes in this case are $9\frac{3}{4}$ in. and 32 in., leaving a space of $22\frac{1}{4}$ in. to accommodate the spring and check-block, and allow for the buffer-spring camber.

3. Guide-plate centre of bolt-holes is shown on the drawing as 13 in., but this varies between 13 and 14 in. The guide-plate bolt-holes nearest to the end-longitude shoulder are $8\frac{1}{2}$ in. to the centre when marking from the longitude shoulder.

The Diagonal

The main function of this frame-member lies in the absorption of the buffer-impact and the maintaining of frame-rigidity. If a wood-frame wagon were built without diagonals, the shock of the buffer-impact would force the frame out of square, and thus make it impossible for the wagon to run on railway tracks. In addition to this, the omission of diagonals would considerably shorten the life of the head-stocks, as, without diagonals, the full force of the buffer-impact would have to be borne by the head-stocks.

It is of interest to note that a considerable proportion of frame repairs, particularly new head-stocks, are due to the faulty fitting and inferior timber of the diagonals. To appreciate fully the importance of having an exact fit for the diagonals, it is necessary to visualize the sequence of forces created by the buffer-impact. The buffer-spring receives the initial impact, but generally owing to prolonged service these springs are weak and the force of the impact is transmitted through the buffer-guide to the head-stock, where it is absorbed by the sole-bar, diagonal, and, finally, the frame. The sole-bar is a solid timber and consequently can withstand the shock, but the diagonal, being fitted at an angle and only held in position by a tenon, has not the rigidity of the sole-bar. Thus, when subjected to the buffer-impact, the diagonal moves towards the sole-bar, which eventually will probably shatter the diagonal where it is fastened to the diagonal-knee. In addition to this, when the diagonal moves towards the sole-bar it is no longer a solid fit to the head-stock, and thus, being unable to withstand the buffer-impact efficiently, causes a severe strain on the head-stock and sole-bar, which may result in the breakage of these two members.

Stripping

1. Check that:

(*a*) The frame is square and level.
(*b*) The width of frame between the sole-bars is correct.

N.B. If the head-stock is curved inwards, new end-longitudes or packing-plates may be required.

2. Remove draw-bar pins, buffer-spring check-blocks, strap-bolts, and tie-rods.
3. Remove and ease rods and bolts to allow the head-stock to be moved sufficiently to permit the removal of the diagonal.

Marking. Replace the head-stock in position.

1. Obtain a lath $3\frac{1}{2}$ in. wide for use as a template.
2. Draw two lines as follows—

(*a*) Across the top face of the middle-bearer continuous with the sole-bar side of the diagonal mortises.

(*b*) Across the top face of the head-stock for the width of the diagonal knees (6 or $6\frac{1}{2}$ in.).

3. Place the lath to touch these guiding-lines and, using the head-stock and middle-bearer as guides, pencil-mark at the middle-bearer end and at the head-stock end on the bottom face of the lath also marking the edge of the end-longitude.

N.B. It is advisable to secure the lath in position by small nails.

4. To mark on the template the position of the short tie-rod, obtain another lath of suitable length, and, placing the straight edge of this lath on the centres of the tie-rod holes in the middle-bearer and head-stock, draw a line where the lath cuts across the template. This line will give the centre-line of the tie-rod through the diagonals.

5. Unfasten the template, add $\frac{1}{8}$ in. to the line from the inside face of the head-stock, and saw the template to shape.

6. Place the template on the top of the new timber, and square the marks down.

7. Obtain the depth of the tie-rod from the top of the diagonal by measuring the centre of tie-rod hole from the top edges of the head-stock and middle-bearer.

8. Measure and mark:

(*a*) The mortise-holes from the top edges of the middle-bearer and head-stock.

(*b*) The depth of the mortises.

(*c*) The length of the tenons.

9. Obtain the position of the diagonal-knee bolt-hole by measuring the distance from the top edge of the diagonal and to the inside of the head-stock (generally 6 in. and $3\frac{1}{2}$ in.).

Fitting

1. Before making the diagonal template, trammel the axle-guards and test the height of the wagon from the top of the rail to the bottom edge of the sole-bar.

2. The diagonal position in the frame forms an angle of approximately 15° to the longitudes, and consequently the tenons at

both ends have to be shaped accordingly to fit into the mortise-holes, with sides squared from the shoulder at 90° or 105°. Therefore the tenons have to be:

(*a*) Slightly reduced in width to give an angle of 90° at the longitude side of the tenon fitting in the middle-bearer.
(*b*) Similarly reduced on the sole-bar side of the tenon fitting in the mortise-hole in the head-stock.

3. The sides of the mortise-hole:

(*a*) Middle-bearer, outside edge;
(*b*) Head-stock, inside edge;

have to be slightly bevelled to suit the angle at which the diagonal is fitted in the frame. This bevel is approximately $\frac{3}{8}$ in. for a mortise $1\frac{1}{2}$ in. deep and $\frac{1}{8}$ in. for a mortise $\frac{1}{2}$ in. deep for the bottom diagonals.

4. The tenon of the diagonal should be $\frac{1}{16}$ in. less in length than the depth of the mortise-hole. This prevents the tenon-end from contacting the bottom of the mortise-hole and allows for the shrinkage of new timber.

The Side-rail

Stripping

1. Remove all necessary bolts.
2. If the wagon has two fast ends, one corner-plate must be removed.
3. If there are enough other repairs, it may be possible to lift the end sufficiently to enable the side-rail to be removed.

Marking

1. Using a lath, place one end level with the outside face of the head-stock and mark on the lath the position of the half-mortise for fitting the side-rail to the head-stock.
2. Mark on the lath:

(*a*) All bolt- and rod-centres.
(*b*) Side-knee mortise.
(*c*) Side-door opening.

3. There are two methods of obtaining the side-door hinge-feet bolt-centres—

1. When the new side-rail is bolted to the sole-bar, fit the side-door in position and mark the position of the hinge-feet bolt-holes, using the door-hinges as a guide.

2. (*a*) Find and mark the centre of the door.

(*b*) Find and mark the centre of a lath the same length as a door.

(*c*) Place the centre-mark of the lath on the centre-mark of the door and mark the door-band feet-holes from the hinge-feet.

(*d*) Place the centre-line of the lath on the centre-line of the side-rail and mark the door-band feet-holes on the side-rail.

3. Obtain the distance of these holes from the top edge of the side-rail by holding the hinge-feet in alinement with the side door and measuring the distance from the centre of the holes to the bottom edge of the side-door plank. Deduct from the measurement $\frac{1}{4}$ in. to allow for the working clearance of the side-door.

The End-pillars

Marking

1. Obtain the length by measuring the depth of the fast end from the bottom edge of the head-stock to the top of the fast-end plank (excluding capping).

2. The taper of the end-pillars commences 2 ft from the bottom and carries through to 3 in. thickness at the top.

3. Bolt-holes in end-planks vary, but are usually in the centre of the plank, with the exception of the top end-planks, which have two bolts.

4. The end-pillar face, which fits to the head-stock, must be straight and square, and the face-edges should have a chamfer of $\frac{1}{2}$ in.

The End-door

There are various types of end-door fastenings, and probably the most common is the gravity-swivel catch-bar (Fig. 20). The essential factors in this type of end-door are as follows—

1. There must be no more play between the roller-bar and the hinge than is necessary for working, and the hinge must hang squarely, as otherwise the door will twist.

2. The catch-bar centre-pin holes in the catch-bar are generally 6 in. out of centre from the handle-end to ensure the gravity-working of the bar.

3. The centre-pin should be shaped with a head $1\frac{1}{2}$ in. diameter, and under the head a collar 1 in. diameter and $\frac{7}{8}$ in. deep, and should be tapered to a $\frac{3}{4}$ in. stem, which is screwed and drilled. The object of this forged collar on the swivel-pin is to enable the catch-bar to work freely when the swivel-pin is tightly screwed.

N.B. Owing to the numerous variations in design, the above measurements are approximate.

4. The catch-bar cover-plates secured to the end-door hinges

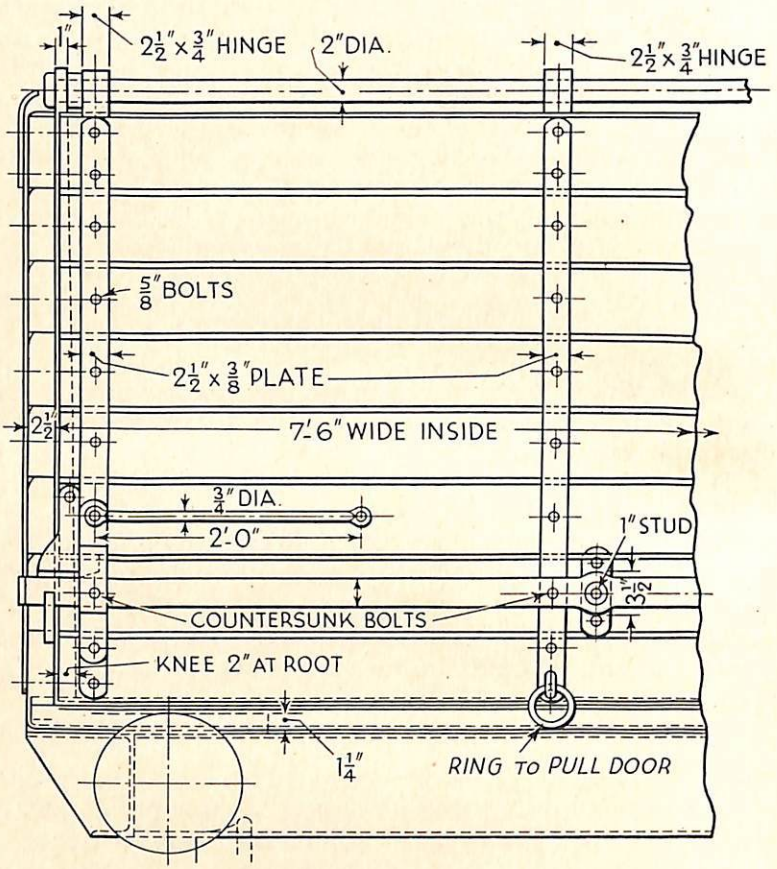


FIG. 20. END-DOOR

are fitted to keep the catch-bar in position, and to prevent bending when the end-door is dropped. These cover-plates when made should have a ⅞ in. space between the inside of the plate and the end-door hinge or washer-strap.

5. The two end-door fastening-hook catches, which are let into the quarter-planks and bolted to the end-door knees, should be so arranged that when the catch-bar is in position it is level across the wagon. The holding-catches should also, when in position, be dead straight, i.e. pointing neither up nor down,

6. The end-door drop-catch is very important. In the 1907 design (Fig. 21) the bolt-holes are $\frac{13}{16}$ in. to facilitate the fitting of a $\frac{7}{8}$ in. long ferrule, with a $\frac{5}{8}$ in. bore inside the hole, thus enabling the bolt to be screwed tightly without fastening the dropper.

7. End-door dee drop-fasteners when in position must be perpendicular to take the strain of the load and must also have an effective hold on the end-door catch-bar to prevent the bar twisting under the strain of the load. Dee drops should be completely welded and made of steel, $2\frac{3}{4} \times \frac{5}{8}$ in. for 3 in. sheeting and $2\frac{1}{4} \times \frac{5}{8}$ in. for $2\frac{1}{2}$ in. sheeting.

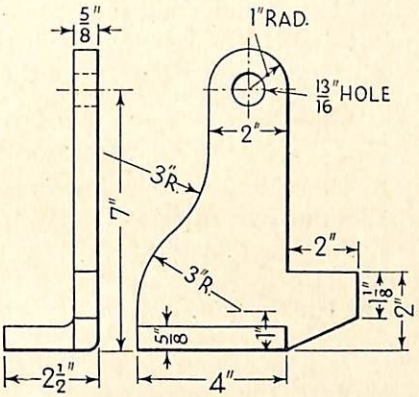


FIG. 21. DETAIL OF CATCH "A" (1907 SPECIFICATION)

End-door bolt-fasteners are the most efficient (Fig. 22).

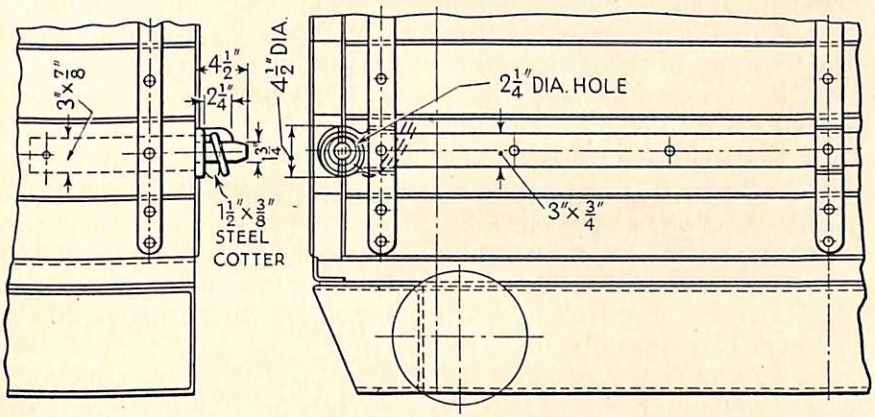


FIG. 22. END-DOOR

END-PLANKS

The correct length of an end-plank is the distance between the outside faces of both side-rails less the thickness of the side-sheeting.

N.B. An alternative method of deciding the length is to take the shoulder-length of the middle-bearer and add the thicknesses of two sole-bars and side-rails, less the thickness of the side-sheeting.

Through-planks

The correct length of through-planks is—

(*a*) The distance between the outside faces of both head-stocks (providing these are correctly fitted).

(*b*) The shoulder-length of the sole-bar plus the thickness of two head-stocks.

Side-door Planks

1. The side-door opening must be square, and the side-door planks must be fitted correctly to the opening.

2. Side-door fasteners are of various designs, but the important factor in each case is to arrange that the dropper or tongue has at least a $\frac{5}{8}$ in. grip on the top of the side-door hinge.

Bottom-doors

1. Mark the position of the bottom-door eye-bolt centres by measuring the fastener-bar (or monkey-tail) from where the eye-bolt fits.

2. Obtain the distance of the eye-bolts from the top of the sole-bar by measuring from the centre of the hinge part of the monkey-tail and adding $\frac{3}{4}$ in. thickness for the bottom-door hinge.

3. Fit the fastener-bar casting on the monkey-tail and obtain the positions of the coach-screw holes, peg, and chain.

4. Fit the saddle-bands on the middle-longitude and follow these with the bottom-door hinges.

5. Reference to drawings shows the following dimensions—

(*a*) Fastener-bar eye-bolt centres 6 in. from the top of the sole-bar and 3 ft 5 in. width.

(*b*) Centre of bottom-door hinges, 2 ft 9 in.

(*c*) Centre of bottom-door saddle-bands, 3 ft $2\frac{1}{4}$ in.

(*d*) Centres of roller-bars between cotter-pin holes, 3 ft $4\frac{3}{4}$ in. Roller-bars, overall, 3 ft $6\frac{3}{4}$ in.

(*e*) Size of bottom-door, 3 ft $6\frac{1}{2}$ in. × 1 ft 10 in. plus $\frac{1}{2}$ in. for clearance gaps.

(*f*) Bottom-door hinges when in position should extend $\frac{3}{4}$ in. beyond the fastener-bar centre.

(*g*) There must be a working clearance of $\frac{1}{4}$ in. round all edges of the door.

PATCH-PLATING WOOD-FRAMED WAGONS (R.C.H. REGULATIONS)

The affixing of patch-plates on the faces of main members of wood-framed wagons is not permitted.

Edge-plates as described below will be permitted; the plates to be 4 in. wide by $\frac{1}{2}$ in. thick; spring-shoe plates to be not less than 4 ft long, secured with six $\frac{5}{8}$ in. bolts; and other plates to be not less than 2 ft 6 in. long, secured with four $\frac{5}{8}$ in. bolts—

(*a*) Horizontal plates put on the lower edge of a main member to provide against the possibility of a development of the defect natural to the growth of the timber, provided the plates are bolted through and not secured by coach-screws.

(*b*) Horizontal plates put on to the lower edge of a main member to strengthen a defect which will be visible after the plates have been affixed, provided that (in addition to the 4 ft spring-shoe plates allowed) not more than one 2 ft 6 in. plate is used for a defect not exceeding $1\frac{3}{4}$ in. in length which runs into a bolt-hole, or for a defect not exceeding 1 in. in length which runs into the solid. The plates to be affixed with bolts and not with coach-screws.

(*c*) Spring-shoe plates not less than 4 ft long by $\frac{1}{2}$ in. thick, secured by six $\frac{5}{8}$ in. bolts, and set up over the spring-shoes to maintain the spring-shoe in its proper position.

(*d*) Spring-shoe plates not less than 4 ft long by $\frac{1}{2}$ in. thick, with $\frac{3}{8}$ in. mild-steel spring-shoes riveted to plate and secured by six $\frac{5}{8}$ in. bolts.

N.B. When a wagon is detained loaded at an out-station with a defective main member, the plates may be secured by $\frac{5}{8}$ in. coach-screws to enable the wagon to complete its loaded journey if compatible with safety, provided the wagon is green-labelled "to works when empty."

The plates referred to below will not be considered as patch plates—

Angles at junctions of head-stocks and sole-bars, and angle-plates or knees at each corner of the wagon, where in either case the attachments were parts of the original design.

Tee strap-bolts and bolt washer-plates.

Top and/or bottom strengthening-plates affixed to tank wagons at the junction of the cross-members, with the sole-bars in cases where the original design causes the whole of the load to be taken on the cross-members.

GENERALLY-REPAIRED WAGONS

Railway Clearing House Regulations relating to the details of generally-repaired wagons are as follows—

"Wagons must be plated at least once in every seven years to the effect that they have been generally repaired, and

wagons in accordance with the foregoing requirements, and which comply with the maximum dimensions set forth in Appendices A and B hereto, will be accepted for G.R. plating. The plates, which are to be provided by the repairer, and to the design shown, must be affixed to the sole-bar in close proximity to the registration-plates after the wagons have been passed out by the Railway Co.'s inspector or examiner."

The above R.C.H. Instruction is wide in its application and requires a more detailed explanation of its essential points—

1. The object of G.R. plating is to ensure that each wagon is thoroughly examined and all its defects made good over a period of seven years.

2. Stress is laid on the importance of:

(*a*) Draw-gear being dismantled and inspected.
(*b*) Broken door washer-straps being renewed.
(*c*) Frame-timbers being in good condition.
(*d*) All iron and steel parts being above the minimum sizes detailed in R.C.H. Regulations, Appendices A and B.
(*e*) Wagons being lifted, and bearings, dust-shields, and under-caps being inspected and, if under size, being renewed to Drawing 95.

3. If sole-bars or middle-bearers have been fitted, the axle-guards and the frame must be trammelled and squared at each corner.

4. The following regulations and minimum dimensions to be adhered to—

(*a*) Buffer-heights from a minimum of 3 ft $3\frac{1}{2}$ in. to 3 ft 6 in., with a variation of $\frac{1}{2}$ in. allowed.
(*b*) Draw-bar pin-holes must not exceed $1\frac{5}{8}$ in. diameter.
(*c*) Buffer-spring blocks must be fitted with clips.
(*d*) Centre of draw-bar pin-holes from the inside of the head-stock $9\frac{1}{8}$ in., with an allowance of $\frac{3}{8}$ in. variation.
(*e*) Clearance gap between the front-plate of the 14-plate buffer-spring and the end-longitude check-blocks to be $2\frac{1}{4}$ in.
(*f*) On standard wagons, side-door cotter-boxes to be secured with an extra bolt to the through-plank.

5. All brakework parts to be in correct working-order, and brake-pins must not fall below 6 in. from rail-level when in their lowest possible position.

6. The method of securing cappings on mineral wagons, shown

on R.C.H. Drawing No. 2075, should be adopted in the case of existing wagons passing through shops for repair—

(*a*) Requiring renewal of side, end or end-door top planks and/or cappings.
(*b*) With loose cappings requiring securing.
(*c*) With cappings not secured with bolts.

HOPPER SELF-EMPTYING FLOOR

When constructing or altering a wagon-floor to a complete hopper-floor, i.e. hoppering-floor, sill, and saddle-planks, it is the usual practice to fit—

(*a*) Bottom-door planks, 3 in. thick.
(*b*) Hopper-saddle, 3 in. thick and built to required width.
(*c*) Floor-planks, $2\frac{1}{2}$ in. thick (sometimes 3 in.).
(*d*) Hopper cross-bearers, 9 × 3 in.
(*e*) Cross-bearer support, 9 × 3 in.
(*f*) Top and bottom cross-bearers, 7 × $2\frac{1}{2}$ in. or 3 in. thick.
(*g*) Side-sill planks generally 7 × $2\frac{1}{2}$ in. in short lengths.
(*h*) Diagonal-braces to cross-bearers, 5 × $2\frac{1}{2}$ in.

If constructional drawings are not supplied, the repairer will be well advised to adopt the following procedure.

Measuring and Marking-out of Templates

1. Clean a level space of floor approximately 8 ft square and make two straight-edged laths for the marking of the diagram.
2. Draw a horizontal line to represent the floor-level of the wagon. At one end of this line draw a line at right-angles to represent the fast end.
3. Mark on the fast-end line the height of the hopper from the floor-line, and on the floor-line mark the distance from the inside of the end-sheeting to the bottom-door edge-planks.
4. Place the lath on these two points and draw a line diagonally to represent the top of the hopper floor-planks.
5. From this line measure the thickness of the floor-planks to be fitted, and connecting these points obtain the position of hopper floor-planks in relation to the floor-level and the fast end.
6. The template can now be made from these lines of hopper floor-planks.

Hopper Cross-bearer Support

1. Find the centre of the hopper plank-line running diagonally from the fast end to the floor-level (hopper floor-line), and at

right-angles to this line draw a line to connect with the floor-level line, thus obtaining the centre and path of the hopper centre-bearer supports.

2. On each side of this centre-line draw the half width of the cross-bearer support (7 in. wide for a 10-ton wagon, 9 in. wide for a 12-ton wagon).

3. Measuring from the centre-line of the cross-bearer support, mark from the top the width and thickness of the plank to be used for hopper cross-bearers.

4. From this diagram make a template of the cross-bearer support.

Hopper Saddle. If the bottom-doors are situated at the underface of the wagon-frame, the width of the hopper-saddle would be the same width as the middle-longitudes outside faces. If the bottom doors are fitted on the top of the frame, the width of the hopper-saddle varies in relation to the type of hinge fitted but, assuming that the kind of doors fitted are to the top of the wagon frame, it would be necessary to—

(*a*) Find the widths of:

(i) Bottom-door sill-planks.
(ii) Bottom-doors.

(*b*) Find the lengths of the saddle-planks.

N.B. These would depend on the size of the bottom-door, which should be as large as possible.

(*c*) Having decided the bottom-door width, i.e. the distance between each door less $\frac{1}{2}$ in. for clearance gap, set out the measurements obtained from the transverse centre-line on the middle-bearer, thus finding the base-width of the hopper-saddle.

N.B. An alternative method is to fit in position oak edge-planks, then bottom-doors and saddles, and bolt and nail these in position.

Hopper-saddle Template. Having obtained the base-width of the hopper-saddle—

1. Draw a line 30 in. long and find and mark the centre.

2. From the centre-mark draw a line at 90° to the original line and approximately 18 in. in length.

3. Mark on the original line, from the centre, the base width of the hopper-saddle.

4. From this base-width draw two lines connecting on the perpendicular line at angles of 45°.

5. This gives the height and base-width of the hopper-saddle from which the template can be made.

Hopper Side-sills

1. Draw lines representing the level of the floor and the inside of the body on the floor-level line.
2. Mark the base-width of the sill and from this width draw a line at 45° to connect with the inside body-line.
3. This gives the base-width and the height of hopper-sills from which the template can be made.

Hopper sill-planks are generally fitted on, and hopper-saddles through, the hopper floor-planks, as this prevents the hopper-saddle from moving when under excessive stresses of unloading. The hopper-saddle should protrude approximately 6 in. beyond the inside of the hopper floor-planks.

To obtain the length of the hopper-saddle—

1. Measure from the outline made for the hopper floor-planks and mark on this outline the height of the hopper-saddle.
2. Draw a line through the hopper-plank—2 in. beyond the thickness of the planks—thus finding the distance from the edge of the bottom-door to the end of the hopper-saddle.
3. Double this measurement and add the length of the bottom-door plus $\frac{1}{2}$ in. allowed for clearance. The final measurement is the length of the hopper-saddle.

Method of Fixing Hoppered Floor. Assuming that the bottom-doors and the hopper-saddle are fitted in position—

1. Fit in position the bottom hopper cross-bearer and nail it to the bottom-door edge-planks.
2. Fasten the top cross-bearer to the end-planks in the same position as in the diagram.
3. Fit in position the cross-bearer supports.
4. Using the hopper floor-planks template, place the template in position on the top and bottom hopper-bearers, and mark a line from the bottom edge of the template.
5. The centre of this line is the centre of the support-block, which should be fitted at right-angles to the line made.
6. Fit in the hopper cross-bearer, and from the bottom edge of the cross-bearer fit two braces 5 × $2\frac{1}{2}$ in. to each corner of the wagon.
7. The hopper-support frame is now in position and the hopper-planks can be fitted.

CHAPTER VI

TANK WAGONS

CONSTRUCTION of tank-mountings—Tank-barrels—Tank wagon rebuilding—Ordinary repairs to tank-mountings

THE repairing of tank wagons and mountings and the methods of securing the tank to the wagon-frame involves many problems, for the solution of which extensive technical knowledge and practical skill are necessary. To seat a tank to the mountings correctly and to secure the tank to the wagon-frame involves many problems and demands accuracy to detail within small limitations. There are many varieties of seating arrangements, and to give a detailed description of each would only tend to confuse the reader, especially in connexion with the obtaining of the radii, lengths, and widths required to mark the mountings to the centres and profiles of the tank; accordingly the general principles will be given, and it will be found that these are applicable to all types of tank wagons.

There are two types of tanks in general use, Rectangular and Cylindrical.

Rectangular Tank. This tank is seated on pitch-pine packings, which vary in thickness from a minimum dimension of $1\frac{1}{2}$ in. The packings are secured to the top of the wagon-frame and the packing-faces must be level both longitudinally and transversely. The tank is also braced at both ends and sides to prevent side-and-end slip during shunting operations; it is secured to the wagon-frame by means of holding-down straps with screw-ends and diagonal-braces. It is interesting to note that in order to facilitate the emptying of this tank the bottom is made to slope towards the centre.

Cylindrical Tank. This is the commonest type of tank, and is fixed to the wagon-frame by means of a superstructure, which is in turn secured by tying-down bands with screwed ends, ropes, etc. These superstructures are termed tank-mountings, and their design may follow either of two principles—

1. The tank is seated on mountings fitted crosswise to the longitudinal direction of the tank. These are called Saddle-mountings.
2. The tank is seated on mountings fitted in the same longitudinal direction as the tank. These are called Cradle-mountings.

The design and strengths of materials required to build either type of tank-mountings are contained in the relevant R.C.H. Drawings and Regulations governing the building and repair of tank wagons. In the following pages a technical survey is made of the methods and principles to apply when making the various

FIG. 23. GLOUCESTER 14-TON CYLINDRICAL TANK WAGON (1930)

templates necessary to mark out the tank-mountings to the exact lengths, widths, and contours of the tank, and to obtain the correct seating of the tank to either saddle- or cradle-mountings.

CONSTRUCTION OF TANK-MOUNTINGS

Saddle-mounting. The parts required in the construction of saddle-mountings are—

1. Two cross-saddles, which fit on the top of the middle- or cross-bearers and support the tank.

2. Two end dish block-stops, which are fitted on top of the head-stocks, and:

(*a*) Support the tank at the ends.
(*b*) Act as a cushion.
(*c*) Prevent the tank from moving endways.

3. Two cross-heads, which are fitted to the tank-ends and positioned on the horizontal centre-line of the tank in order to—

(*a*) Act as a cushion.
(*b*) Prevent movement of the tank endways.

The timber to be used for these mountings, as designated on R.C.H. Drawings, is pitch-pine, athough sound oak is permitted as a substitute. The sizes of these timbers vary considerably, as all these members are shaped to the circular and elliptical contours of the tank.

Cradle-mounting. This method of mounting consists of—

1. Two cradle-bearers fitted longitudinally to the full length of the wagon-frame over head-stocks. The bearers are spaced apart according to the diameter of the tank, and are fastened by means of—

(*a*) Truss-rods shaped to the contour of the tank.
(*b*) Cleats bolted to the bearers.

The average width and depth of these cradle-bearers is 7 × 7 in.

2. Two end dish-stops which are fitted at the ends of the cradle-bearers, and perform the same purpose as explained under "Saddle-mounting," the only difference being that in cradle-mountings the end dish-stops and the cradle-bearers are jointed to each other.

3. Two cross-heads which are fitted in the same position and perform the same purpose as explained under "Saddle-mounting."

It is advisable when repairing tank-wagon frames and mountings to refer to the R.C.H. Drawings and Regulations appertaining to tank construction and repair, both wood and steel—

Standard 1927 R.C.H. Drawing No. 1200
Standard 1913 R.C.H. Drawing No. 108
Standard 1911 R.C.H. Drawings Nos. 97 and 98

Other useful Drawings are R.C.H. Nos. 72, 73, 74; while Drawing No. 107, 10-, 12-, and 14-ton, November, 1913, covers tanks carrying sulphuric acid.

When dealing with a tank-wagon frame, the renewals and repairs are as explained in the chapters dealing with wagon repairing and rebuilding, but particular attention must be paid to the following points—

1. The width of the frame between the sole-bars must be accurate; no variation of any kind is allowed:

1911 Specification, 6 ft 1 in.
1923 Specification and steel frames, 6 ft 3 in.

2. The squaring of axle-guards must be accurate—the maximum variation allowed is $\frac{1}{4}$ in.

3. Buffer-centres:

1911 Specification, 5 ft $8\frac{1}{2}$ in.
1923 Specification, 5 ft 8 in.

4. The maximum variation allowed in the height of the side bearing-springs, measured from the top of the axle-box spring-seats to the bottom face of the sole-bar, is $\frac{1}{4}$ in., and it is advisable to work to a mean measurement of $\frac{1}{8}$ in.

5. Draw-bar pins to R.C.H. P.O./C.L. 53, September, 1932 (Fig. 24).

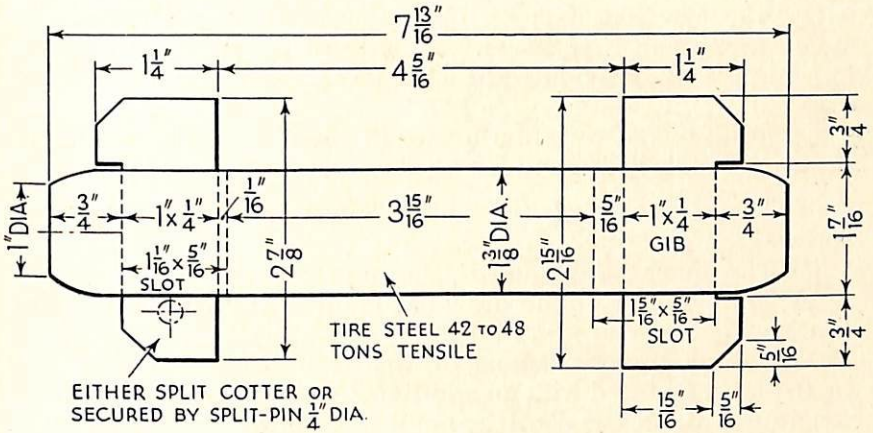


FIG. 24. DRAW-BAR PIN
(To R.C.H. P.O./C.L. 53, September, 1932.)

N.B. Draw-bar pins in accordance with Fig. 24 may be used in cases where the standard bolt cannot be fitted without lifting the tank barrel. A subsequent Addendum, P.O./C.L. 57, gives permission for the double cotter-pin to be used as an alternative to the standard bolt on all tank wagons.

6. Cradle-stops must be fitted to the draw-bar cradle. The purposes fulfilled by the fitting of cradle-stops inside the cradle and between the middle-longitudes (or fastened to the middle-bearer) are—

(*a*) Stop fitted inside the cradle: if the intermediate draw-bar, when taking the pulling-strain as part of a train, should break, the energy contained in the now-released draw-bar spring would impel the nut and part of the intermediate draw-bar with great force against the tank outlet-stool. Thus the cradle-stops inside the cradle protect the tank outlet-stool from damage or injury in this manner.

(*b*) Stops fitted between the middle-longitudes and fastened to the middle-bearers: these stops are fixed in order to control the

movement of the draw-bar cradle, when taking the pulling-strain, as part of a train, within defined limits. If the intermediate draw-bar should fail, these stops prevent the stops inside the cradle from damaging the tank outlet-stool.

N.B. R.C.H. P.O./C.L. 55. Draw-bar cradles for tanks with bottom outlets are to be fitted with safety-stops in accordance with Drawings Nos. 1043–5; in cases where the position of the stool varies from that shown on the drawing, the stop may be altered to suit, providing the clearances are maintained. (See Fig. 25.)

7. Owing to the variation in size of the tank outlet-stool, the draw-bar cradle width and length must conform to—

(*a*) The diameter of the outlet-flange or rubber draw-bar springs.

(*b*) The dimensions *A* and *B*, shown in Fig. 25.

(*c*) The position of the draw-bar cradle between the middle-bearers.

N.B. Tank wagons having draw-gear to Drawings Nos. 163 or 164 must be fitted with an additional stop between the middle-longitudes at each end of the cradle. If, however, the latter is too close to the middle-bearers to admit of the use of these stops, wood stop-blocks must be fitted and must bear against the middle-bearer, the space between the end of the cradle and the stop-block to be $2\frac{1}{2}$ in.

8. Cradle-carriers must be fitted to tank wagons with bottom outlet built prior to 1927.

9. Wagon-frame ironwork must conform to the R.C.H. Regulations, Appendices A and B. Tank iron and steel fittings are to be as detailed in the regulations governing tank construction.

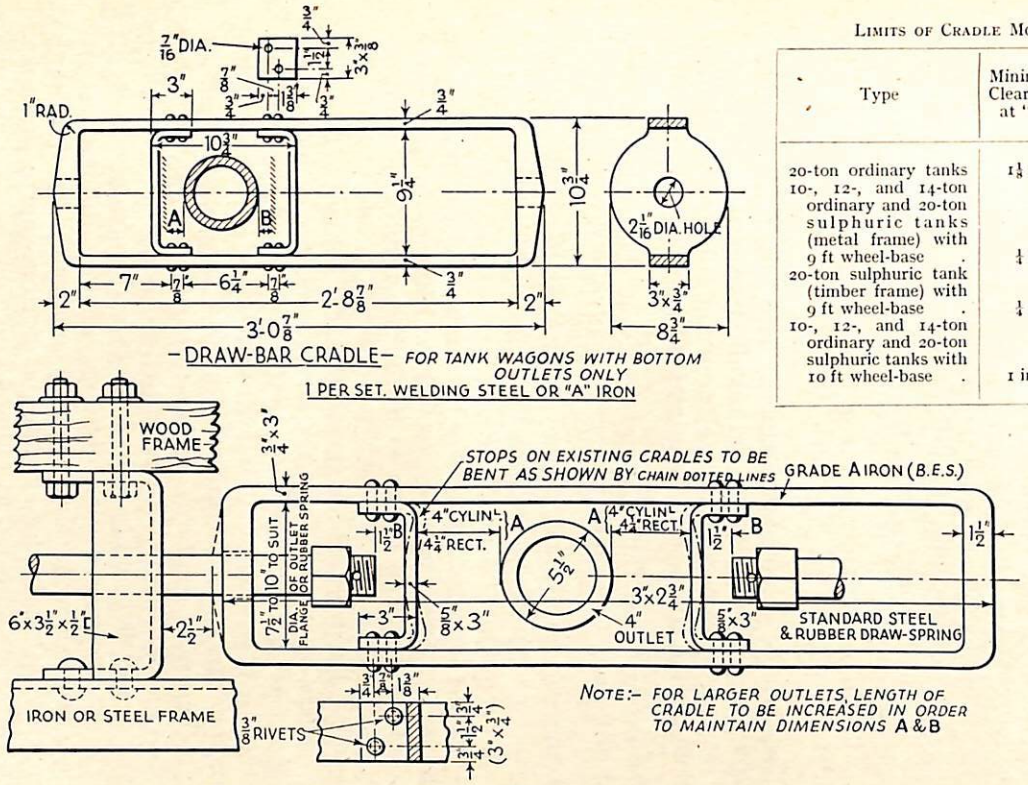
Checking the Levelness of the Wagon-frame. One rule must be observed before proceeding with the fitting of tank-mountings to the wagon-frame: the wagon-frame must be of equal height at each of the four corners. This is ensured by testing the levelness of tank frame with a spirit-level

1. Fasten the wheels by fixing wedges.

2. Cut lengths of wood to the exact lengths if required and fix at each corner of the frame, and check by the spirit-level.

It must be stressed that if the wagon-frame is not the same height at the ends and sides—

(*a*) The level of the wagon-frame members to each other will be inaccurate.



LIMITS OF CRADLE MOVEMENT

Type	Minimum Clearance at "A"	Minimum Clearance at "B"
20-ton ordinary tanks	1 1/8 in.	1/8 in.
10-, 12-, and 14-ton ordinary and 20-ton sulphuric tanks (metal frame) with 9 ft wheel-base	1/4 in.	1 3/8 in.
20-ton sulphuric tank (timber frame) with 9 ft wheel-base	1/4 in.	1 7/8 in.
10-, 12-, and 14-ton ordinary and 20-ton sulphuric tanks with 10 ft wheel-base	1 in.	1 in.

FIG. 25. DETAILS OF TANK WAGON WITH BOTTOM OUTLET

(1911 Specification, Drawing No. 169, January, 1917; alteration to position of safety-stops in draw-bar cradles, items 4 and 5, Drawing No. 18B.) Tank wagons having draw-gear to Drawings Nos. 163 or 164 to be fitted with an additional stop at each end of cradle, asshown; but when the cradle is too close to the middle-bearers to admit of the use of these stops, wood stop-blocks must be fitted, *bearing against the middle-bearers.*

(*b*) The measurement obtained for the fitting of tank-mountings to the wagon-frame will affect the correct fitting and tying-down of the tank to the mountings.

When the repairs to the tank wagon are completed and it is ready for final inspection, the wagon must be placed on a straight and level track, or the checking of side bearing-spring heights will not be accurate. In addition to this, where facilities for lifting and dropping the tank on its mountings are not available, the tying-down of the tank should not be done until the wagon-frame is of equal height, from the rail to the top face of the wagon-frame, at each corner.

Generally, in a wood-frame wagon that has been in service for a considerable period, say, twenty years—

(*a*) The cross-bearer tenons, owing to wear, affect the levelness of the top faces of the sole-bar and middle-bearers.

(*b*) Head-stocks sometimes wear below the sole-bar top face.

(*c*) Sole-bars in some cases are slightly bowed.

It is necessary that these differences should be measured; the method of finding these measurements is as follows—

1. If the sole-bars are straight longitudinally along the top face, place a straight-edged board across both sole-bars, positioned on the middle-bearers.

2. Check the levelness of middle-bearers to the top face of the sole-bars and, if there is any difference, nail (temporarily) a strip of wood of the required thickness to the top face of the middle-bearers.

3. Test the longitudinal levelness of head-stocks in relation to middle-bearers by using a length of string weighted at both ends, and placing suitable packings under the string and the top face of the head-stocks. Manipulate with packings until the string contacts the top face of the middle- or cross-bearers, or the strips nailed to the top of the bearers; the taut string should be loose on the top of the bearers. A straight-edged board placed on the bearers or packings could be substituted for the string.

4. The measurements thus obtained of any differences are very important when marking out tank-mountings (to the depth between the top of the frame and the bottom-centre of tank). Differences can be adjusted as follows—

(*a*) The wagon-frame cross-members can be repositioned, if new.

(*b*) An oak-wood strip, the full width of the frame-member and to the required thickness, can be fitted and screwed down to the member.

(*c*) The difference could be made up by increasing the depth between the bottom of the tank and the top of the frame-member, when marking out the mounting, by allowing the difference ascertained.

If the sole-bars are acutely bowed, it is advisable to fit new sole-bars. If the sole-bars are only slightly bowed, to find the dimension of the concave dip—

1. Test the transversal levels of cross-members, as explained previously.

2. Obtain a straight-edged board, the full length of the wagon-frame, and place it in the centre of the bearers (or strips of wood) on the top face, and measure the space between the bottom edge of the board and the top face of the frame-member concerned, from the front face of the head-stock, the level position of the board, and the dipped position of the head-stock. These measurements of differences will give the bevel to be shaped on the bottom face of the end dish-stops and also the dimensions to be allowed when marking out the end-stop. An alternative method of finding the depth of the concave of a bent sole-bar which has warped longitudinally is to—

1. Obtain the centre of the sole-bar.

2. Measure 1 in. from the top face of the sole-bar, at the tenon-shoulders, and mark or make a saw-cut at this position (at both ends of the sole-bar).

3. Using a length of string pulled tightly and positioned in the saw-grooves or on the pencil-mark, measuring from the top face of the sole-bar on the centre-line to the bottom point of the string, obtain the measurement of the deformation from the longitudinal straightness, deducting from this figure 1 in. (movement 2).

Steel wagon-frame joints are definitely stronger than wood frames, and are free from the wear of tenons and mortise-holes of wood-frame wagon joints; but it is necessary to check the longitudinal levelness of the cross-bearers and head-stocks, plus rack-plates—

1. Clean all corrosion from the rack-plate.

2. Test with a length of string longitudinally the top-face level of frame cross-members and rack-plates.

3. The difference must be allowed when marking out the tank-mountings.

Marking-out of Tank-mountings. In preparation for the fitting of cross-saddles and end dish-stops (see Fig. 26)—

1. Obtain the centres of each head-stock and bearer.

2. Square these centre-lines down approximately 4 in. on the sides of the bearers facing the end of the wagon and on the front faces of the head-stocks.

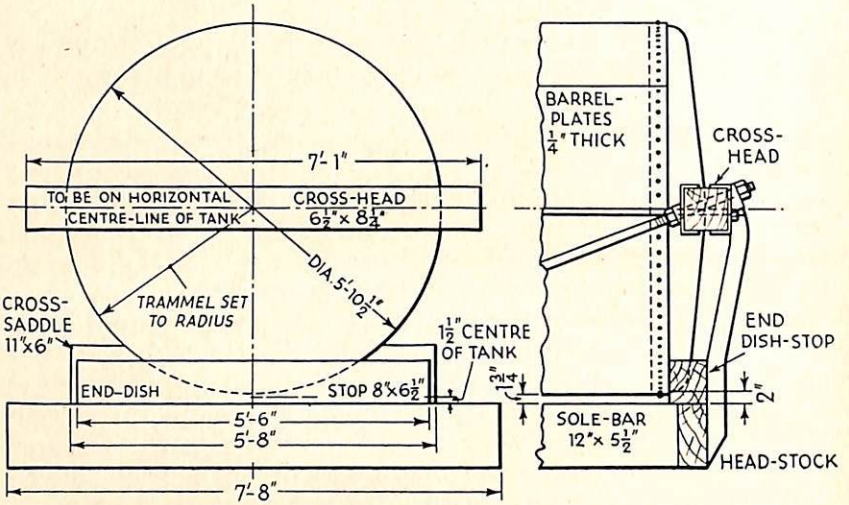


FIG. 26. STANDARD SADDLE-MOUNTING

N.B. The reason for these guiding-lines is that when fitting the cross-saddles and end-stops the centre-lines marked on these tank-mountings would be fitted accurately to the longitudinal centre of the wagon-frame, thus ensuring the vertical centre alinement of the tank in relation to the longitudinal centre of the wagon-frame.

The wagon-frame has now been prepared for the fitting in position of new tank-mountings. The technicalities of marking out the necessary templates to the radii, dimensions, and position of the tank, as it is seated to the mountings and to the wagon-frame, are obtained by drawing full-scale diagrams. These diagrams detail the shapes to be cut out of the mountings, in order to seat the tank in its relation to the horizontal position of the wagon-frame.

To accomplish this, a drawing site is required about 15 ft square.

Drawing the Diagram to Mark Out Cross-saddle Template

1. Draw a horizontal line about 8 ft 0 in. long (this line represents the transversal top face of the middle-bearers).

2. Obtain the centre of 1.

3. Measure the length of the cross-saddle and, spacing each end equally from the centre, mark them on line 1 (for the purpose of clearer explanation, designate these two length-marks as *A* and *B*).

4. Set the trammel points to the length of cross-saddle, place one point on *A*, and move the other end of the trammel to strike an arc above the centre of 2.

5. Repeat this process from *B* and it will be found that the two arcs intersect.

6. Draw a line connecting the point of intersection with the centre-line marked on 2, thus obtaining a true line at 90° (which represents the line from the vertical centre of the tank to the transversal position and centre of the wagon-frame).

7. Measuring from 1 and on the centre-line, mark $1\frac{1}{2}$ in. (this is the space between the bottom-centre of the tank and the top of the wagon-frame).

8. Set the trammel to half the diameter of the tank.

9. Place one point of the trammel on 7 and the other point of the trammel on the vertical centre-line (this point is the pivot). With the point placed on 7, strike the radius of the tank-barrel.

The diagram has now been drawn of the tank as it is seated to the cross-saddle, and the template can now be marked out from the diagram as follows—

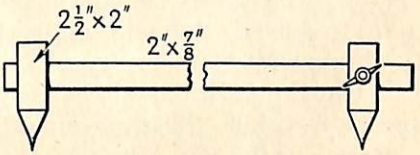


FIG. 27. ONE TYPE OF TRAMMEL

1. Prepare a board the same length and width as the cross-saddle, $\frac{3}{4}$ in. thick.

2. Obtain the exact centre of this board, and square the centre-line across the board.

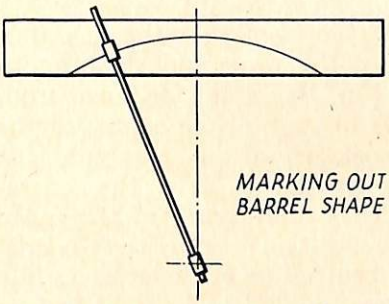


FIG. 28. MARKING OUT THE BARREL SHAPE

3. Place the board on the diagram, centre-lines meeting, and the bottom edge of the board placed in alinement with line No. 1. Fasten with two screws.

4. Place the trammel in the previous position 9 and strike the radius of the tank-barrel on the board.

5. When the board has been shaped to the lines marked, check

the template on the tank-barrel. If correct, the template can be used to mark out the cross-saddles.

Marking-out of Cross-saddle. Obtain the exact centre of the cross-saddle and square lines across all faces. Place template in position, centre-lines contacting, and mark radii of the tank-barrel. Also mark the horizontal centres of the diagonal tie-rod holes; obtain other bolt-hole centres from the wagon-frame.

To obtain the pitch of the diagonal tie-rod holes to be bored out of the cross-saddle and end cross-head, as these mountings are positioned on the wagon-frame—

1. Draw a line about 10 ft 0 in. long (this line represents the top face of the sole-bar).
2. On one end of line 1 draw a vertical line about 6 in. long (this line represents the centre of the sole-bar).
3. Measure from line 2 the length from the centre of the sole-bar to the front face of the end cross-head.
4. Draw a vertical line from the mark positioning the front face of the cross-head, about 5 ft 0 in. long.
5. Draw the position and outline of the cross-saddle and cross-head as they will be fixed to the wagon-frame, on lines 1 and 4.
6. Draw on the diagram the exact position of the diagonal tie-rod, which will cut through the outline of the cross-saddle and cross-head, thus obtaining the angle of the tie-rods as they fit through these mountings.

When the positions of the tie-rod holes have been marked on the cross-saddle, this tank-mounting can be machined.

Fitting of End Barrel-plates to the Cross-saddle. Tank-barrels constructed of three plates are so designed that the lap-joint fastening end and middle plates together are positioned on the centre of the cross-saddle. When dealing with a tank of this construction it is necessary to—

1. Add the thickness of the middle barrel-plate to the clearance space between the bottom-centre of the tank and the wagon-frame. If the barrel-plates are a $\frac{1}{4}$ in. thick, the distance from the bottom face of the cross-saddle to the bottom-centre of the tank would be $1\frac{3}{4}$ in. at the head-stock side of the cross-saddle.
2. To obtain the position of the rivet-heads, place the centre-line of the template in line with the bottom-centre of the tank, and mark on to the template the position of the rivet-heads. The template is now placed on the centre-line of the cross-saddle and the marks continued on the cross-saddle.

Finding the Diameter of the Tank-barrel. There are several

ways of finding the diameter of the tank-barrel for the purpose of marking out tank-mountings—

METHOD I

1. Remove the manhole cover and mark off on the manhole side the exact longitudinal centre of the tank-barrel.

2. Using a staff about 8 ft 0 in. long, place this staff into the tank in line with the longitudinal centre marked on the side of the manhole and held in a true vertical position. Press the bottom-end of the staff to the inside of the middle barrel-plate, making sure that this end of the staff is resting on the bottom-centre of the tank-barrel.

3. Mark on the staff the position of the middle barrel-plate (inside face) positioned at the top-centre of the tank-barrel.

4. Measure the distance between the bottom end of the staff and the mark positioning the inside of the middle barrel-plate at the top-centre.

5. Add to the measurement obtained the thickness of the middle plate doubled. The final figure is the diameter of the tank-barrel's outside dimensions (within the limit of small variations).

METHOD II

1. Obtain the diameter of the end-plate by using the trammel. Place the fixed point of the trammel on the top-centre of the tank and adjust the movable end of the trammel until the exact diameter of the tank end-plate is obtained.

2. Measure the distance between the trammel points, and to the figure obtained add twice the thickness of each barrel-plate. The remainder is the outside diameter of the middle tank-plate.

Formulae for Various Barrel Dimensions and Capacities

c = Circumference $= 2\pi r = \pi d$

d = Diameter $= \frac{c}{\pi}$

r = Radius $= \frac{d}{2} = \frac{c}{2\pi}$

a = Area $= \pi r^2 = \frac{\pi}{4} d^2$

v = Volume $= al = \frac{\pi}{4} d^2 l$

l = Length

$\pi = 3\frac{1}{7} = 3{\cdot}1416.$

End Dish-stop. The marking-out of the end-stop must be very accurately performed to the various radii of the tank end-plate, in order to ensure support and the prevention of tank movement during shunting operations.

To understand the process of obtaining the various radii of the end-plate, consider as an example a tank constructed of three-plate laminated barrels with plates $\frac{1}{4}$ in. thick (the same principles would apply to any number or various thicknesses of barrel-plates). As the space between the bottom-centre of the tank and the top face of the wagon-frame at the centre of the middle plate is $1\frac{1}{2}$ in., the distance from the top face of the head-stock to the bottom-centre of the end-plate would be the thicknesses of the middle and end barrel-plates added to the centre clearance space; $1\frac{1}{2}$ in. plus two plates $\frac{1}{2}$ in. thick equals 2 in. Thus the distance between the bottom-centre of the tank end-plate and the top face of the head-stock is 2 in. To this figure must be added $\frac{1}{16}$ in. for the compression of new joints and any differences found when testing the longitudinal levelness of the wagon-frame must be added to the $2\frac{1}{16}$ in.

Preparation of the End-stop Template. The diagram drawn for the marking-out of cross-saddle templates can be used again—

1. Obtain a board the same length and depth as the end stop, about $\frac{3}{4}$ in. thick, mark one side the inside face, and mark two edges top and bottom.
2. Find the centre of the board, and square a line across the board and edges (centring the board).
3. On this line, 2, measure from the bottom edge of the board $2\frac{1}{16}$ in. (the space between tank and frame).
4. Place the board on the diagram, the centre-linee contacting and in true alinement with the horizontal line (No. 1 cross-saddle diagram).
5. Obtain the diameter of the tank end-plate and reset the trammel to half the measurement obtained.
6. Place one point of the trammel on 3 ($2\frac{1}{16}$ in. from the bottom face) and the other point of the trammel on the centre-line (vertical).
7. Strike across the board the circular shape of the end tank-plate, thus marking out the template to an end elevation of the circular shape of the end-plate.

It is now necessary to obtain a side elevation of the elliptical dished shape of the end-plate—

1. Draw a vertical centre-line on the tank end-plate, centring

the tank longitudinally (this line is necessary also for the centre positioning of the tank when seating the tank to the mountings).

2. The position of the top face of the end-stop must be marked on the tank end-plate (the end-stop is assumed to be 10 in. by 10 in.).

3. Deduct from this figure of 10 in. the distance between the tank and the top of the frame, $2\frac{1}{16}$ in. The remainder is $7\frac{15}{16}$ in.

4. To allow for the compression of new joints, deduct $\frac{1}{16}$ in. The remainder would be $7\frac{7}{8}$ in., which is the depth the tank end-plate fits into the end-stop.

5. Measuring $7\frac{7}{8}$ in. from the bottom centre-line marked on the tank end, 1, draw a horizontal line across the end-plate (denote the ends of this line as *C* and *D*). This line must form a true angle of 90°.

6. To test if the above line forms a true angle of 90° to the vertical line, place the fixed point of the trammel on the exact top-centre of the vertical line, then adjust the movable end of the trammel to contact *C*, and fasten it to this position; swing the trammel across the end-plate to *D*. Any divergence from the distance the trammel was set to at *C* proves that the line is not true and must be rectified.

The tank end-plate has been marked with the position of the top face of the end-stop. It is necessary to prepare a template of the contour of the tank end-plate at this point, guided by this line.

1. Using a board $\frac{3}{4}$ in. thick and approximately the same length as the end-stop, obtain the centre of the board and square this centre across the board.

2. Press the board to the tank end-plate, the centre-lines meeting and in alinement with the line positioning the top face of the end-stop.

3. Measure the spaces between the inside edges of the board and the end-plate at each end of the board.

4. Fasten on the board at each end two strips of wood, which will protrude to the length obtained, and replace the board in the same position as described in 2 (the strips prevent movement of the board).

5. With the guiding-tool mark out the contour of the tank end-plate on the board. (See Fig. 29.)

The board when cut to the lines marked is the template. To mark out the top face of the end-stop, two short templates are

required to mark the vertical depth of the tank end-plate contour to be cut out of the end-stop; these templates are obtained from the horizontal-contour template.

Convex and concave templates are required to mark out and shape the end-stop to the vertical contour of the end-plate.

To find the depth, the tank-end fits into the end-stop (endways)—

1. Find the centre of the wagon-frame transversely (centre of sole-bar) and measure the length of the tank-barrel to the outer edges of the end barrel-plates (if both ends were removed, obtain the extreme length of the remaining barrel-plates).
2. Measuring from the sole-bar centre-line, mark on the sole-bar the length of the tank-barrel and equate either side of the centre-line.
3. Measuring from this length of the barrel, mark on the sole-bar the depth of the end-plate contour to the longitudinal centre of the tank; this can be obtained from the horizontal-contour template.
4. Take from the measurement obtained $\frac{1}{16}$ in. for compression of new joints at each end.
5. Measure from the front face of the head-stock the remaining space between the front face of the head-stock and the defined length of the tank; this dimension is the limiting depth the tank fits into the end-stop longitudinally.

The end-stop can now be marked to the dimensions obtained. With the template—

1. Centre the end-stop and square this centre-line round all faces, measuring from the front face. On the centre-line, mark the limiting dimension obtained as in 5 (distance between the length of the tank and the front face of the head-stock).
2. Place the end-contour template on the top face of the end-stop, the centre-lines meeting and the apex of the contour placed exactly on the mark which determines the position of the tank end-plate (as in 5).
3. Having marked the top face of the end-stop, turn the stop over to mark out the inside face. Measure $2\frac{1}{16}$ in. from the bottom face and, using the circumference template, mark on the end-stop the radius of the tank end-plate; the end-stop is now ready for shaping. It should be noted that if the end-stop is to be fitted into an end-stop channel, the thickness of the channel must be allowed when marking on the end-stop the depth the tank fits into the end-stop longitudinally.

N.B. In dealing with tank end-plates that are corroded, it is advisable to allow $\frac{1}{8}$ in. instead of $\frac{1}{16}$ in. in order to achieve a good fit.

Tank Cross-head. The end cross-head fits on the horizontal centre-line of the tank end-plate. It is necessary to prepare a template to mark out the cross-head to the contour of the tank end-plate—

1. Find the exact horizontal centre of the tank end-plate and mark this position on the vertical line already marked on the end-plate.
2. Either side of the centre-mark, measure the width of the cross-head and mark on the vertical line. Draw these two lines across the end-plate. These lines must be accurate at 90° to the vertical line.
3. To test for trueness, check with the trammel from either the bottom- or the top-centre of the tank (as very few tanks are exactly alike, the cross-head varies in its position on the tank-end). The horizontal lines positioning the cross-head should be made to suit the individual tank.
4. Obtain a board $\frac{3}{4}$ in. thick and the same width as the new cross-head. Find the centre of this board and square a line across the board.
5. Press the board on the tank end-plate, taking care that the centre-lines contact and that it is level with the top horizontal cross-head line. Measure the distance between the end of the board and the tank end-plate.
6. Take the board down and fasten to it two strips of wood, protruding from the inside edge of the board to the required length.
7. Hold the completed board in position and press it to the tank end-plate, centre-lines meeting and the top face of the board in alinement with the horizontal line positioning the top face of the cross-head.

As soon as the shape of the tank end-plate as it fits to the top face of the cross-head has been marked out, the board will be ready to be marked out, with the aid of the marking-out tool, to the contours of the tank end-plate—

1. Place the board $\frac{1}{4}$ in. below the line positioning the bottom face of the cross-head, and mark on the board the contour of the tank end-plate in this position. When the board has been shaped to the narrowest contour the template is ready for using. Mark off the cross-head from the template. (If the cross-head is positioned centred to the horizontal centre of the tank-end

there will not be any difference between top and bottom contours.)

2. Next shape the template to the larger contour and mark this shape on the cross-head, thus obtaining the shape to be cut out of the cross-head to fit the tank end-plate, or make separate templates.

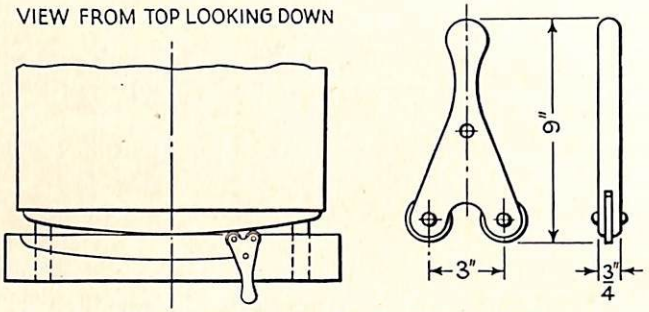


FIG. 29. MARKING OUT THE CROSS-HEAD OR DISH-BLOCK

The shape of the tank end-plate between the top and bottom face lines marked on the tank end-plate must be obtained in order to make a template of the vertical contours—

1. Press a suitable piece of squared strip-wood, about 1 ft long, on the vertical centre-line of the tank-end and centred with the horizontal centre-line of the cross-head.

2. Hold it firmly in this position, and measure the space between the edge of the lath and the end-plate.

3. Draw on the lath the shape of the end-plate between the cross-head lines

4. Shape the lath to this mark, and from this template mark a convex template which can be used to obtain the correct fit of the cross-head to the tank end-plate.

5. To obtain a good fit of the cross-head, when having it machined leave the line in about an $\frac{1}{8}$ in. at the centre. This ensures that the cross-head fits tightly to the centre of the tank-end and prevents the end-thrust of the tank more efficiently.

N.B. The method of finding the distance between the front face of the cross-head (the face that fits to the channel) and the overall length of the tank to the centres of the end-plates—

1. Obtain the length of the barrel, measure the depth of the end-plate contour with the aid of the cross-head template, double this dimension, and add to the barrel-length.

2. The thicknesses of cross-heads vary, but very seldom are they less than 6 in. There should be at the very least $3\frac{1}{2}$ in. of

solid timber left after the cross-head has been shaped, which added to the thickness of the channel is $3\frac{7}{8}$ in. Double this figure equals $7\frac{3}{4}$ in.

3. If straight end-stanchions are fitted, it is a simple comparison between the overall length of the barrel and the length over the head-stocks, the thickness of cross-heads being adjusted within the limitations of efficiency.

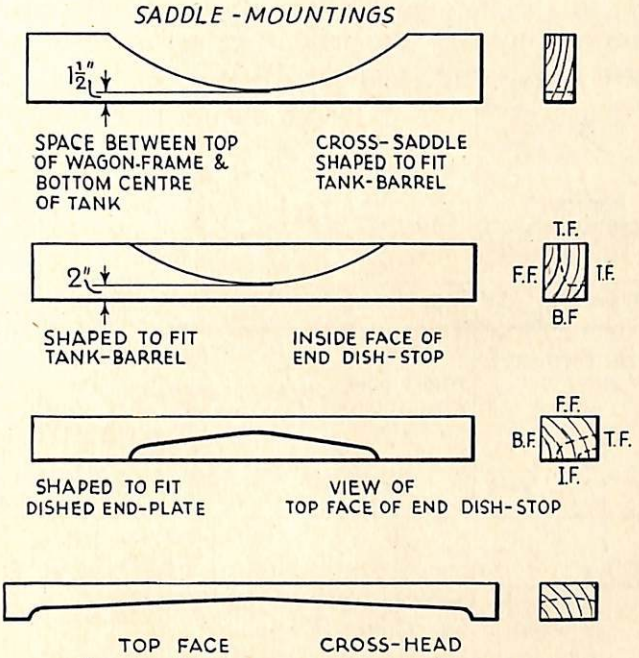


FIG. 30. SADDLE-MOUNTING AND CROSS-HEAD

4. If the end-stanchions are cranked inwards or, as they generally are, outwards, to find the depth of crank, either bolt in position or obtain a straight-edged board, place one edge on the inside of the end-stanchion (the side that fits to the head-stock), and measure the distance between the edge of the board and the inside face of the channel. Double the measurement obtained.

5. Add to measurement 4 the length of the wagon over the head-stocks.

6. Deduct measurement 1 from 5.

7. The remainder is the thickness of two cross-heads at the apex of the contours. Half the remainder is the measurement for one cross-head.

The position of diagonal tie-rods as they fit through the cross-head can be obtained from the diagram drawn to mark out cross-saddle templates.

This completes the technical principles to be followed when marking out tank-mountings to the cross-saddle design.

Cradle-mountings. The arrangement of this design of tank-mountings is based on the principle of seating the tank longitudinally. It therefore gives a larger area of resistance to tank movement and involves considerably less wear on the mountings

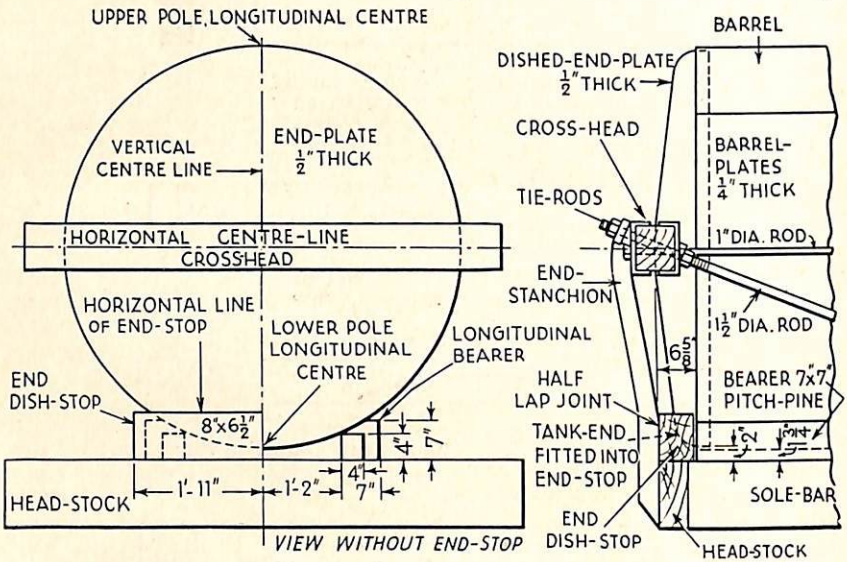


FIG. 31. CRADLE-MOUNTING

compared with the opposite principle of seating the tank cross-saddle.

The arrangement of cradle-seating is constructed on the wagon-frame by fixing two "longitudinal bearers" the full length of the wagon-frame. These bearers, made of pitch-pine, are spaced apart according to the diameter of the tank-barrel at equal distances from the longitudinal centre of the wagon-frame (somewhere between 2 ft 0 in. and 2 ft 8 in.). The section of these timbers varies, as the size is based on the load-ton weight to be supported; some are 6 × 6 in. and others 7 × 7 in. The ends of the bearers are jointed into the end-stop.

The parts comprising cradle-mountings are two longitudinal bearers, two end-stops, and two end cross-heads—and the necessary tying-down bands, ropes, and tie-rods, which when positioned

will securely tie the tank to the mountings and to the wagon-frame.

Assuming that all repairs to the wagon-frame have been carried out, and that the top-face level of the wagon-frame is correct or that the dimensions of differences have been taken, and also that the height from the rail to the top face of the wagon-frame is equal (or has been made so) at all four corners of the wagon, the marking-out and fitting of the cradle-mounting to the wagon-frame can be proceeded with—

1. The new longitudinal bearers must be fitted in the same position on the wagon-frame as the previous ones, or placed to a position defined by the applicable R.C.H. drawings.

2. Preparation of the wagon-frame for the fitting of longitudinal bearers is necessary. Obtain the exact length-centres of head-stocks and middle-bearers, and square these centre-lines across the top face of these frame-members; continue these centre-lines to the front faces of both head-stocks about 4 in. long.

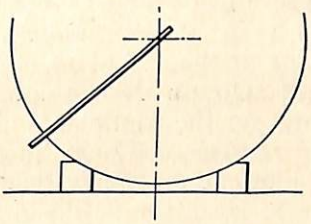


FIG. 32. MARKING OUT

3. To test the true longitudinal alinement of these centres, using a length of string weighted at both ends, place the string on the head-stock centre-lines and check the alinement of string with the centre-lines marked on the middle-bearers. Any deviation from true centre alinement can be seen and rectified.

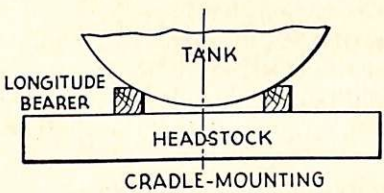


FIG. 33. MARKING OUT

4. Measure from these centre-lines the "width between" longitudinal bearers, and mark on the top face of all the members.

5. Measuring from these lines, mark the width of the longitudinal bearers. The lines marked on the top face of the wagon-frame position the longitudinal bearers in relation to the longitudinal centre of the wagon-frame.

The next stage is to mark and shape the longitudinal bearers to the radius of the tank and in relation to their position on the wagon-frame. To obtain these measurements, it is necessary to draw an end elevation of these parts, as shown in Fig. 32.

1. Draw a horizontal line about 7 ft 0 in. long (this line represents the top face of the head-stock).

2. Find the centre of this line, and from this centre draw a

vertical line at 90° to the horizontal line and about 8 ft 0 in. long (this line represents the vertical centre of the tank and is also the longitudinal centre of the wagon-frame).

3. Mark on the head-stock line, measuring from each side of the centre-line, the position of the longitudinal bearers, as set out on the wagon-frame.

4. Measuring from the head-stock line (1) mark the thickness of the longitudinal bearers.

5. Measuring from the head-stock line (1) along the vertical line (2), mark the clearance space dimension between the bottom-centre of the tank and the top of the wagon-frame, $1\frac{1}{2}$ in.

N.B. A tank-barrel constructed of three sections of steel plate $\frac{1}{4}$ in. thick would have a clearance space between tank and frame of $1\frac{1}{2}$ in. at the middle-plate, $1\frac{3}{4}$ in. at the end barrel-plate, and 2 in. at the end-plate.

6. Obtain the diameter of the middle-plate of the tank-barrel and set the trammel-points to half this dimension.

7. Place one point of the trammel on the $1\frac{1}{2}$ in. mark and the pivot end on the vertical line.

8. Mark the radius of the barrel on the diagram.

9. To mark the radius of the end barrel-plates, readjust the movable end of the trammel $\frac{1}{4}$ in. shorter, and draw through diagram.

From the diagram measurements can be obtained to mark accurately templates and longitudinal bearers.

To locate the position in which the tank-barrel will fit longitudinally on the cradle-bearers in relation to the cross-centre of the wagon-frame—

1. Obtain the longitudinal centre of the sole-bar, and square this centre-line across the top face of the sole-bar.

2. Measure the length of the middle barrel-plate longitudinally and mark this length equally spaced either side of the centre-line (1).

3. Measure the length of the end barrel-plates and mark the length obtained from the length-lines of the middle barrel-plate on the sole-bar.

The position of the cradle-bearers on the wagon-frame and the seating of the tank on the cradle-bearers have been arrived at, and the marking-out of the new longitudinal cradle-bearers can be proceeded with as follows (it is assumed that the timber has been sized and cut to length)—

1. Obtain the longitudinal centre and from this mark off all dimensions arrived at.

2. Mark off templates from the diagram and shape them. Concave and convex are required to mark and shape the cradle-bearer to fit the tank.

3. Mark out end-joints and tie-rod holes, also ordinary bolt-holes.

This completes the marking-out of longitudinal bearers to accommodate the tank to the lengthwise and crosswise centres of the wagon-frame. All bolt- and rod-holes can be obtained from the applicable drawings. The end dish-stops and cross-heads are marked out as detailed in the section dealing with the construction of saddle-mountings.

N.B. As regards the trammel, this tool can be made any length that is required. It has one fixed point and one end that will slide up or down the shaft, and is secured tightly in any position by manipulating a thumb-screw (Fig. 27).

Fitting the Tank to the Mountings. The vertical line connecting the upper and lower poles of the tank circumference; the centre-line marked on the head-stock front faces, which is continued to the top face of the end dish-stop; and the horizontal line positioning the top face of the end dish-stop, marked on the end of the tank, will show any deviation from true centre when lowering the tank into position. If a true check is required, check the crosswise levelness of the wagon-frame with a spirit-level. The true perpendicular position of the tank, in relation to the horizontal plane of the wagon-frame, can be obtained by using a weighted length of string from the top-centre of the tank and checking its alinement with the centre-lines marked on the head-stock and the end dish-stop. On completion of the fitting of the tank to the mountings—

1. Fix in position the holding-down bands.
2. Fit and fasten in position cross-heads and barrel-ropes.

Equal strain on the wagon-frame should be maintained when tightening up rods and bolts, for unequal strain will cause the weight of the tank to be eased off the side-spring where the strain is most acute, thus allowing the camber of the side-spring to be increased, which will disturb the equality of space between the top of the axle-box and the bottom face of the sole-bar. In addition the wheel at the corner, with the acute strain on the tying-down bands or ropes, not having weight at that corner, will tend to run off the track.

To test if the strain of holding-down ironwork, rods, etc., is evenly distributed, manipulate a crowbar placed under each

wheel in turn; the degree of hand pressure necessary to ease the wheel-tire off the rail should be equal, but if one corner is light it will easily be noticed, and determines the corner at which the ropes or bands have been screwed up too tightly. This can be rectified by readjusting the strain of these fastening components.

TANK-BARRELS

The bottom outlet-valve must be a very good fit. The control mechanism of this valve, which is positioned at the top-centre of the tank-barrel, is in some designs placed outside the tank; in others, inside the tank-dome. Control is by means of a hand-wheel and screwed rod. It is essential that the hand-wheel seating centred at the top of the tank-barrel should be in true alinement with the valve mechanism positioned at the bottom-centre of the barrel, as otherwise valve efficiency will be impaired. (See Fig. 34.)

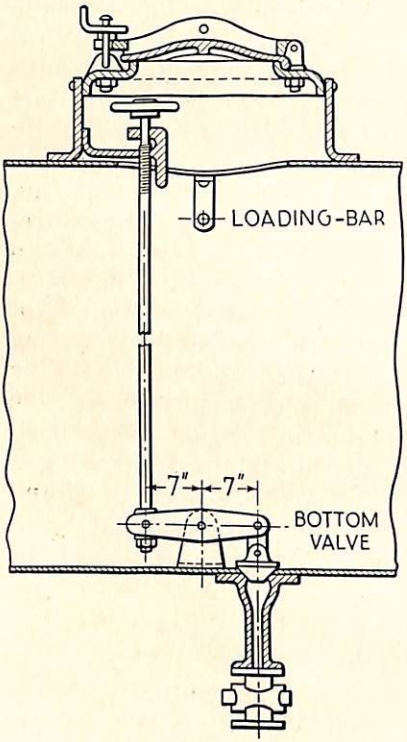


FIG. 34. BOTTOM OUTLET-VALVE

The bottom outlet, if protruding through the brake vee-irons, should have a minimum space of $\frac{3}{4}$ in. from the inside of the brake vee-iron leg to the outside diameter of the outlet-pipe; also this pipe should be supported by loops with lateral freedom.

Siphon Outlet, Discharge-pipe, and Air-vent. Used for emptying the tank of inflammable fluids. (Figs. 35–37.)

Cleaning the Tank-barrel. Before any kind of repairs are investigated, defective tanks should be thoroughly cleaned inside by a process of steaming.

Examining Tank-barrels for Corrosion. Corroded barrel- or end-plates should be inspected to ascertain the mean thickness of places eaten into by corrosion. This is carried out by drilling a hole through the plate or plates at the assumed thinnest place, this hole enabling the accurate thickness of the plate to be measured.

End-plates require particular attention where they have been bearing against the end-stop and cross-head.

Loading-bar or Brackets. A loading-bar must be fitted to all

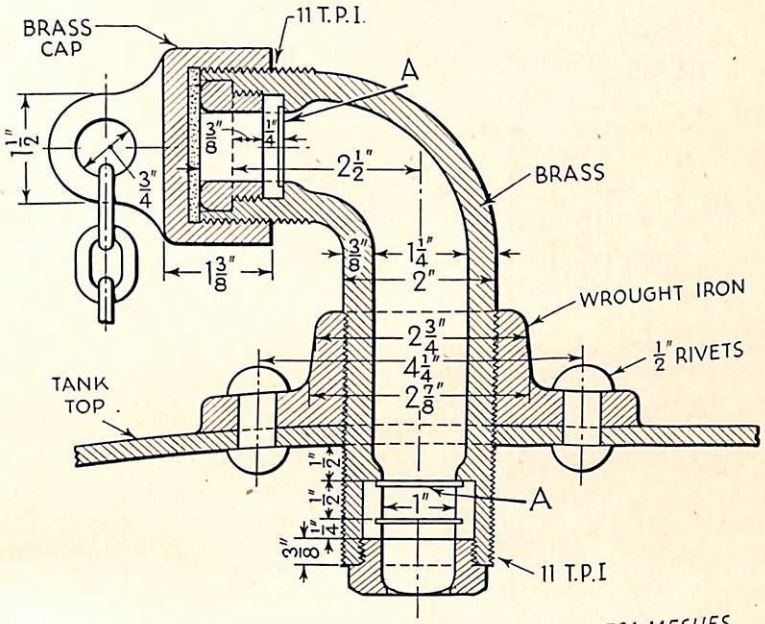


FIG. 35. AIR-VENT

tanks, or else specially-shaped brackets (see Figs. 39, 40), to indicate the level above which the tank must not be filled. This bar is positioned on the horizontal line of the tank-barrel, and is supported with brackets of $2\frac{1}{2} \times \frac{3}{8}$ in. mild-steel plate fixed so that the vertical side of the bracket is in line with the inside of the manhole. The other part of the bracket is fastened to the barrel with two rivets. The loading-bar is 1 in. in diameter, and is secured in position by two split cotters fitted inside the brackets. The length between the underside of the barrel-plate, as measured from the top-centre of the barrel to the centre of the loading-bar, is determined by the degree of fluid expansion, and is as shown on page 109.

Strengthening of Barrel. All tanks of over 5 ft 0 in. diameter inside centre barrel and with barrel-plates $\frac{1}{4}$ in. or $\frac{5}{16}$ in. thick require to be fitted with cross-stays, as shown in Fig. 39. This

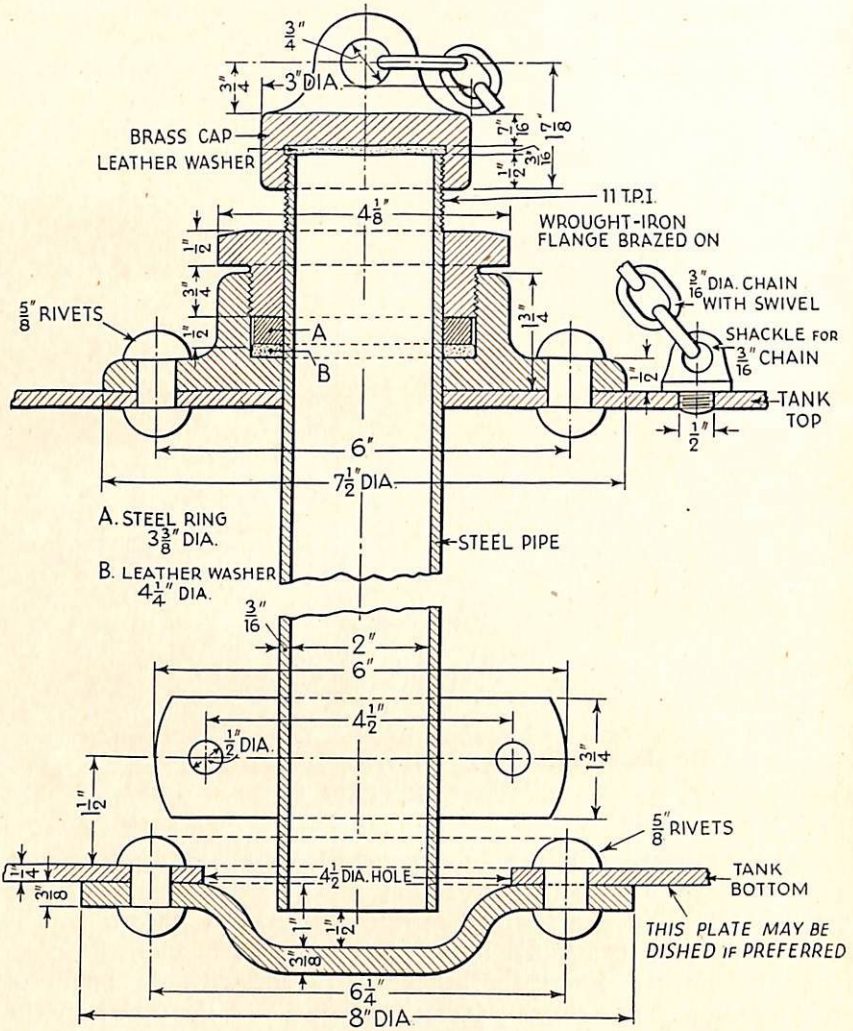


FIG. 36. DISCHARGE-PIPE

requirement does not apply to tanks having other means of stiffening the barrels, e.g. reinforced asphalt or other lining necessary for the conveyance of corrosive liquids.

Variable Loads. If the tank has to carry variable loads, it should be strengthened with additional end baffle-plates, fitted to neutralize the movement of the load, to Drawing No. 79A, 1911, applicable to tank wagons built prior to 1927. The following

FLUID EXPANSION

Diameter inside centre barrel *A*	Inside crown to top of loading-bar *B*	Expansion allowance per cent	Registered load tons
5 ft 7½ in.	5 in. 5 in. 3⅜ in.	4 4 1½	10 12 14
5 ft 10½ in.	5 in. 8⅛ in. 5 in. 3⅜ in.	4 7½ 4 1½	10 10 12 14
6 ft 2⅞ in.	6½ in. 9⅞ in. 6½ in. 9⅞ in.	4 7½ 4 7½	12 12 14 14
6 ft 7½ in.	9⅜ in. 9⅜ in. 6 in.	7½ 7½ 4	10 12 14
7 ft 2⅛ in.	11¼ in.	7½	14

notice must be fitted on the sole-bars: "This tank is specially constructed to allow for variable loads half full."

Alinement of Barrel. If new barrel-plates have been fitted, the longitudinal alinement of repaired barrel must be true. One method of checking the alinement is—

1. Mark the horizontal centre of the tank on the sides of the end-plate.
2. Obtain two strips of wood about 1 ft 0 in. long by 1½ in. square.
3. Obtain the centre of strips and square this line round all faces.
4. Shape one side of the strip to fit the circular-shaped side of the end-plate *B*.
5. On the opposite side to *B*, cut a small vee or saw-cut on the centre-line.
6. Tie a length of string round the tank and place the shaped strips of wood under the string and centre-lines, contacting the horizontal centre-line marked on the tank end-plate.
7. To check the true alinement of the tank-barrel, measure the space between the string and barrel-plates. Any deviation from true alinement can then easily be seen.

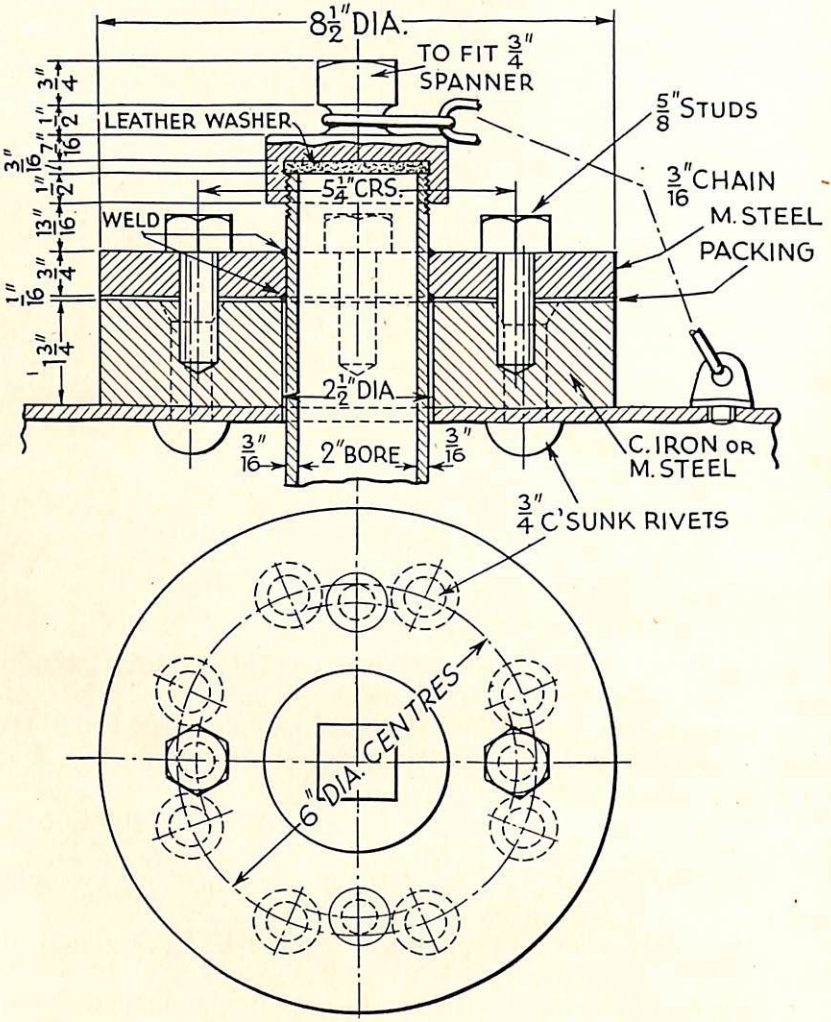


FIG. 37. DETAILS OF SIPHON-TUBE FOR CLASS "A" TANKS (1927 SPECIFICATION)

Testing of Tanks. If repairs have been carried out to the tank, when the repairs are complete the tank must be pressure-tested hydraulically to a pressure of 25 lb per sq. in. Where tanks carry a load that is pumped into the tank under pressure, it is necessary to test to a much higher pressure; in the case of chlorine, new barrels are tested hydraulically to a pressure of 350 lb per sq. in.

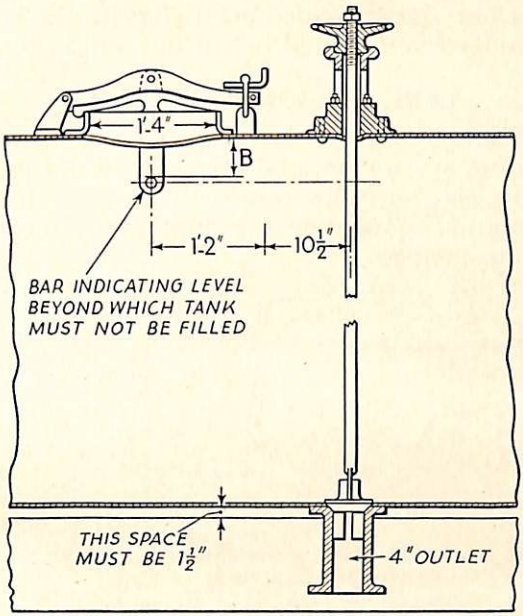


FIG. 38. 1927 STANDARD BOTTOM OUTLET-VALVE

For details of screw-down gear see Drawing No. 1214. For details of manhole see Drawing No. 1213. Other approved forms of manhole or screw-down gear may be used if desired.

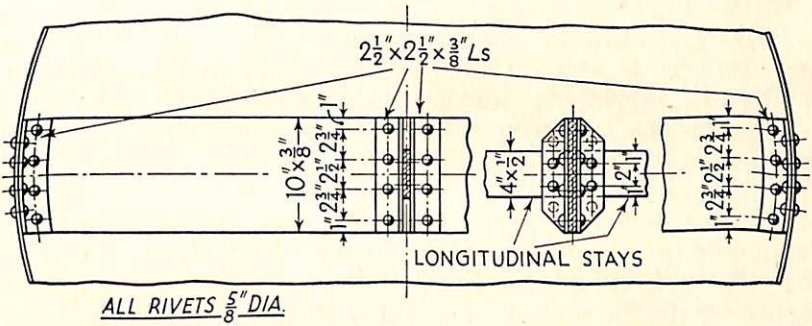


FIG. 39. ARRANGEMENT OF CROSS-STAYS FOR TANKS

(generally these barrels are lap-welded, a 4 or 5 in. lap-joint being formed). Also in some circumstances the test is carried, with compressed air, to a pressure of 50 lb per sq. in. To enable a leakage to be observed, the barrel surface is painted with a soap solution, which quickly shows where a weep is taking place. When the point of leakage is found, if welded, the faulty weld

should be cut out and re-welded or, if riveted, the plate caulking or series of faulty rivets should be cut out and re-riveted.

TANK WAGON REBUILDING

The renewals and repairs to the wagon-frame are as for re-building an ordinary wagon, and are covered in Chapter V. The rebuilt tank wagon must conform in all constructional details to R.C.H. Regulations governing the minimum dimensions of iron and steel components.

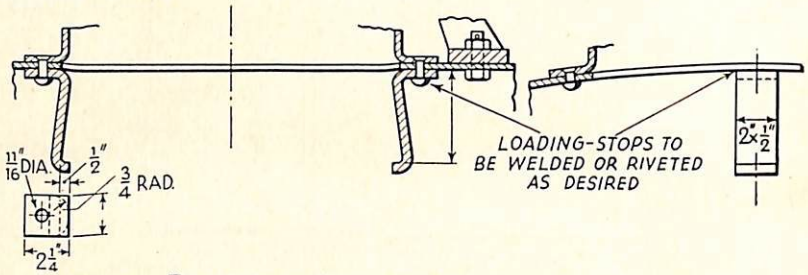


FIG. 40. BRACKETS AT SIDE OF MANHOLE TO INDICATE LEVEL ABOVE WHICH TANK MUST NOT BE FILLED

The important constructional points to bear in mind before submitting the repaired tank wagon for approval to the railway company inspector are as follows—

1. Test to ensure that underframe is level and square.
2. With steel frames, make sure that rivets are not loose. If any are loose to such an extent that they cannot be effectively caulked, the defective rivets must be cut out and new rivets fitted.
3. Check bearing-spring camber: from the underside of sole-bars to the top of the axle-box spring seat should not vary more than $\frac{1}{4}$ in. all round.
4. Check tying-up of the tank-barrel to the underframe by examining the condition of bands, ropes, diagonal-stay, rods, and through-rods; also tank-barrel seatings on the mountings and mountings to the underframe, which on wood underframes may be very unevenly distributed. Ensure that the tank-barrel is central in both the longitudinal and the horizontal or vertical planes.
5. Inspect brakework and components; see that all cotters are in position and adjust-holes are available.
6. Check buffer-rods for correct projection, 18 in. with correct stroke.
7. Check buffer-heights at all four corners.

8. Inspect buffer-springs (laminated) and check the camber 12½ in. from the front plate of the spring at the centre to the inside of the head-stock.

9. Inspect draw-gear throughout: draw-bars, intermediate bars, cradle, and bearer; and cradle-stops, if of bottom-outlet type.

10. Inspect cradle, cradle-carriers (angle, bolt, or steel flat bar).

11. The cradle should be fitted with stops to Class B barrels, i.e. with outlet-stools, pipes, or valves, projecting through the cradle, to safeguard the stool in the event of an intermediate bar failing in service.

12. Check the clearance between cradle-stops and outlet-stools, pipes, or valve, to allow for the compression of springs, steel and rubber.

13. Inspect wheels, tire thickness and profile, diameters of two wheels on one axle, axle sizes at the middle, and wheel-seats, journals where possible.

N.B. Wheel diameters must not vary more than $\frac{1}{16}$ in. on the same axle, or $\frac{3}{4}$ in. end to end.

14. Check axle-boxes where possible (if open-front type should all be the same type with same thickness of liner), also bearings and pads.

15. Where the tank-barrel is fixed to the underframe with wing-plates, it is very essential to check each wheel with a crow-bar for light corners.

Starring of Tank Wagons to Run on Fast Goods Trains (as for Rebuilds). Tank wagons with a wheel-base of not less than 9 ft 0 in., and having the draw- and buffing-gear, wheels and axles, in accordance with the 1907 Specification, also oil axle-boxes with bearings lined with white metal (the axle-boxes must be the same type and uniform in all other respects), may be run on fast goods trains, at an average speed of 35 miles per hour from point to point.

When the foregoing conditions have been complied with, the owners must paint upon each side of the tank, at cross corners, a star, which must be black for light-coloured tanks and white for dark-coloured tanks; while the starring railway company will affix to the underframe special plates showing their initials, the registered number of the wagon, with the letter "A" affixed, and the month and year of starring, the painted star and plate to be to specified design.

ORDINARY REPAIRS TO TANK-MOUNTINGS

The foregoing technical description of obtaining the outline of the tank to prepare templates for the marking-out and shaping of new mountings to accommodate the tank is not applicable for minor repairs to the tank-mountings; for example, the renewal of one end dish-stop, or for cases where the cross-saddle and longitudinal bearers can be repaired by splicing or lining up. The procedure generally adopted for minor repairs to tank-mountings is to observe closely the friction wear of the tank into the mountings and the correct position of the tank, both longitudinally and horizontally, and to note the measurements of differences obtained.

To illustrate these factors, consider a tank wagon which does not require rebuilding or to be generally repaired, but is a light repair, i.e. it requires the renewal of one dish-stop. This repair can be carried out without the tank-barrel being removed if the following conditions are fulfilled—

(*a*) There must be a reasonable space between the top of the wagon-frame and the bottom-centre of the tank.

(*b*) Any wear that has taken place to the end-stop, owing to the movement of the tank, must be observed and accurately measured.

(*c*) The tank should be seated correctly in relation to the longitudinal and horizontal centres of the wagon-frame.

Removal of End Dish-stop. Remove the cross-head and end-stanchions. The end-stop can then be removed; in the case of an end-stop that is fitted to a steel angle, the cross-head and end-stanchions do not need removing. The tank-barrel must be untied and eased off the mountings, the end of the tank being raised sufficiently to enable the end-stop to be removed. The new end dish-stop (pitch-pine or oak wood) must be straight-grained, sawn true to size, and of sound-quality timber. The shaping of the new end-stop can be obtained from the end-stop which has been removed: add to these measurements the wear noted in the defective end-stop previous to the removal, and to that measurement add $\frac{3}{16}$ in. to ensure the tight fitting of the tank-barrel to the end-stop.

Splicing or Lining of Tank-mountings. Mountings that are of sound condition, except for wear caused by the movement of the tank and the wagon-frame, can be spliced with new timber to enable the clearance between the bottom-centre of the tank and the top face of the wagon-frame to be maintained at the correct

dimensions. This is an economical method of repair to worn cross- or cradle-mountings.

The method usually adopted when executing a splicing repair to tank-mountings is as follows—

(*a*) Careful measurements must be made of the existing "space" between the bottom-centre of the tank-barrel and the top face of the wagon-frame; and of the wear of the tank endways into the end-stop.

(*b*) The tank must be removed.

(*c*) The mountings having been removed, the friction-wear of the wagon-frame on the underside of the tank-mountings can be measured and the mountings sawn lengthwise to the depth required; the bottom face is now a straight and true face.

(*d*) Select sound new timber, pitch-pine or oak, the length and width of the mounting to be stripped and of a thickness determined by (*a*) and (*c*), to enable the clearance space between the bottom-centre of the tank-barrel and the top of the wagon-frame to be at least 1½ in., and the end-stop to be a tight fit to the tank end. When this is in position, secure the liner to the mounting with screws.

This completes the technical details concerning the lining-up and splicing of tank-mountings.

Example: Cross-saddle Mounting

1. Existing space between the bottom-centre of the tank-barrel and the top face of the wagon-frame is ¾ in., and wear of the tank end into the end-stop is ¾ in.

2. The tank is untied and removed, thus freeing the mountings for stripping from the wagon-frame.

3. It will be seen that friction wear to a depth of ¼ in. has taken place on the bottom face of the cross-saddle. This mounting should be sawn lengthwise to a depth of ¼ in. The bottom face of the mounting will now be straight and true.

4. Obtaining the thickness of liner.

The clearance space between the bottom-centre of the tank and the top of the frame is ¾ in. Deduct this figure from the intended clearance, usually 1½ in., which leaves ¾ in.; add to this measurement the ¼ in. sawn off the bottom face of the mounting, equals 1 in. The thickness of liner required would be 1 in. The liner having been sawn to the required dimensions, it can be fixed to the bottom face of the cross-saddle.

5. The end-stop requires a liner 1 in. thick (owing to the lifting of the tank) fitting to the front face, and a liner fitting to the

bottom face the same thickness as fitted to the cross-saddle, adding $\frac{1}{16}$ in. to this measurement to ensure the tight fitting of the tank to repaired mountings.

Longitudinal bearers are, when of sound timber, repaired to the same methods as detailed for saddle-mountings.

General Remarks. If it is impossible to obtain measurements from the defective mounting, the methods to be employed to obtain the correct measurements are fully described in previous pages dealing with the marking-out of new tank-mountings.

In the ordinary repairing of tank wagons, where the repair has necessitated the easing of tying-down ropes, bands, and rods, the re-tying of the tank to the wagon-frame must be carried out on a perfectly level road (track) to ensure correct carriage and that the tank is properly seated to the mountings. It may be necessary to ease the tank from the wagon-frame to reduce high places in the concave surfaces of the mountings; or the tank may have rolled slightly out of its true perpendicular centre position. If there is not available a machine to correct the position of the tank, this can be accomplished by using a screw bottle-jack and an oak packing shaped to fit over the intermediate bar. When the jack is in position, the barrel can be moved and any minor adjustments made where necessary.

CHAPTER VII

REBUILDING

REQUIREMENTS of R.C.H. Regulations—Stripping preparatory to rebuilding—Marking out wagon-frame members—Erection and squaring

REQUIREMENTS OF R.C.H. REGULATIONS

THE Railway Clearing House Regulations governing the rebuilding of wagons stipulate that reconstructed and converted wagons will not be accepted for registration as rebuilds; but wagons built prior to 1911 which are so far worn as to require replacement of the following frame-members:

(*a*) two sole-bars, or
(*b*) one sole-bar and three cross-members,

must be rebuilt in accordance with the conditions enumerated in Clause 29–43 of R.C.H. Regulations.

In connexion with this, it should be noted that the time-limit for the fitting of a sole-bar or any main member is one year; and also that when wood under frames of ordinary wagons built to the 1907 and prior specifications are replaced, the dimensions must be in accordance with the 1907 specification and drawings.

A clarification of the preceding paragraph is as follows—

1. When rebuilding a wagon it is not necessary to renew any sound main members that conform to the Specification in other respects: e.g. wagons built prior to 1907 were constructed with head-stocks 5 in. thick, and should these be sound at the time of rebuilding it is not necessary to renew them.

N.B. Should these head-stocks be renewed at a later date, they must be replaced by head-stocks $5\frac{1}{2}$ in. thick, which will necessitate major alterations to the wagon-frame:

(*a*) The sole-bars and side-rails must be shortened $\frac{1}{2}$ in. to accommodate a head-stock $5\frac{1}{2}$ in. thick.

(*b*) Diagonal-knees need to be repositioned.

(*c*) The buffer-spring is moved back $\frac{1}{2}$ in. to maintain correct compression and the camber at 7 in., thus causing the front check-blocks and draw-bar hook to be $\frac{1}{2}$ in. short, and intermediate draw-bar and buffer-spring rear check-blocks to be $\frac{1}{2}$ in. long.

(*d*) Buffer-rams and strap-bolts are also $\frac{1}{2}$ in. short.

2. Iron and steel mountings may be used again, provided that they are in good condition and also that they comply with the minimum dimensions given in Appendix B of the R.C.H. Regulations and conform to the 1907 specification.

N.B. If any of these parts are renewed at a *later date*, the renewals must be in accordance with the 1911 specification and addenda.

There are exceptions to the above paragraphs; it must be noted that the following wagon parts are necessary if they do not comply with the 1911 specification, irrespective of whether the part removed is in good condition.

1. *Draw-gear.* The following parts to be fitted—

(*a*) A 2 ft draw-bar cradle.
(*b*) One set of draw-bar rubbers.
(*c*) One $7\frac{3}{8}$ in. volute spring and accessories.
(*d*) Two gedges draw-bar hooks.
(*e*) Two sets of gedges coupling-links.
(*f*) Two intermediate draw-bars, if replaced, to be of 8C steel.
(*g*) Draw-bar pin cover-plates $7 \times 7 \times \frac{1}{4}$ in., which must be let in level with floor-plank surface.

2. *Brakework.* The following regulations to be adhered to—

(*a*) Hand-brakes to be fitted at both sides of the wagon.
(*b*) The centre safety-loop to be bolted to back vee-iron.
(*c*) The push-rod safety-carriers to be bolted to middle-bearers.
(*d*) The brake-lever pins must not be below 6 in. from the rail level when in their lowest position (when the wagon is loaded).

3. *Buffer-gear*

(*a*) Two 14-plate laminated buffer-springs to be fitted.
(*b*) The existing buffer-guides to be packed with oak packings, or new guides to be fitted $11\frac{1}{2}$ in. from the base to the top of the buffer.
(*c*) The length from the face of the buffer-ram head to the face of the head-stock to be 1 ft 6 in.
(*d*) Buffer-ram lengths from the inside of the head to the cotter-holes:

(i) 5 in. head-stock — 24 in.
(ii) $5\frac{1}{2}$ in. head-stock — $24\frac{1}{2}$ in.
(iii) 6 in. head-stock — 25 in.

(*e*) The buffer-ram stroke to be 5 in.
(*f*) The diagonal-knees to be 4 in. wide.
(*g*) The distance between the first plate of the buffer-spring,

measured as near the centre as possible, to the inside face of the head-stock to be 12½ in.

(*h*) The space between the front plate of the buffer-spring and the end-longitude front check-block to be 2¼ in.

(*i*) The clearance from the front plate of the buffer-spring to the diagonal front block to be 1 in.

(*j*) The buffer-spring wearing-plates to be bolted to the diagonal under-beds.

(*k*) The buffer-spring rear check-blocks to be fitted with steel clips, which must be secured by a cross-bolt.

4. *Strap-bolts and Rods*

(*a*) Four strap-bolts and centre-plates to be fitted at each corner of the wagon.

(*b*) The following rods to be fitted—

(i) 2 1 in. dia. longitudinal through-rods.
(ii) 4 1 in. dia. diagonal tie-rods.
(iii) 4 ⅞ in. dia. cross-rods.

5. *Side-doors*

(*a*) Side-door bang-springs and striking-plates secured with bolts to be fitted at either side of the wagon.

(*b*) Side cotter-boxes of approved design to be fitted at either side of the wagon.

(*c*) Through side-doors to have a clearance of 8 in. from the top of the rail when in their lowest position.

(*d*) Side-door hinge washer-straps to be in good condition.

6. *Body*

(*a*) Diagonal body-braces to be fitted.

(*b*) All cappings to be secured with capping clips.

N.B. 5 clips to each side, 3 clips to each end.

7. *Bottom- and End-doors*

(*a*) Fasteners to be of approved designs.

(*b*) All washer-plates to be in good condition.

(*c*) All ironwork to be above minimum dimensions.

8. *Side Bearing-springs and Shoes*

(*a*) Bearing-spring shoes to be secured to the sole-bar by bolts and to be replaced when worn $\frac{3}{16}$ in. hollow.

(*b*) Axle-guards, if renewed, to be 3 ft 0 in. centres and $3\frac{3}{4} \times \frac{3}{4}$ in. legs.

(*c*) Side bearing-springs to be 4 in. wide, 3 ft 6 in. centres, and the ends to be bolted through the spring-shoes.

(*d*) Side bearing-springs must be uniform in the number and section of spring-plates.

8-ton wagon may be fitted with 8 plates, 4 × ½ in.
10-ton capacity wagons—9 plates, 4 × ½ in.; or 5 plates, 4 × ⅝ in.
12-ton wagons—5 plates, 4 × ⅝ in.
15-ton wagons—6 plates, 4 × ⅝ in.
20-ton wagons—7 plates, 4 × ⅝ in.

9. *Axle-boxes*

(*a*) Axle-boxes must be 2½ in. centres.

N.B. Axle-boxes may be used again, providing they are in good condition and are of approved design.

(*b*) The bearings, if renewed, to be to D9 No. 95 deep-lugged type.

(*c*) The grease-chambers to have a capacity of not less than 90 cub in.

(*d*) Dust-shields must be fitted.

(*e*) A bolt must be fitted through the box beneath the journal.

10. *Wheels and Axles*

(*a*) The journal-centres must be 6 ft 6 in.

(*b*) The wheels and axles must conform to the minimum dimensions for the tonnage carried, as set forth in Appendix A of R.C.H. Regulations.

Any wagons built to special design, or having special constructional details, can, if the railway company concerned approves, be rebuilt retaining these special details of design.

Rebuilding Limitations

(*a*) Wheel-base must be not less than 7 ft 6 in.
(*b*) Buffer-centres to be 5 ft 8½ in.
(*c*) Width between sole-bars to be 6 ft 1 in.
(*d*) Width between bearing-spring shoe-centres to be 6 ft 6 in.
(*e*) Width between wheel-tires to be 4 ft 5⅝ in.
(*f*) Centres of wheel-journals to be 6 ft 6 in.
(*g*) The maximum variation in camber of bearing-springs on an empty wagon to be ½ in., as measured between the underside of the sole-bar and the axle-box spring seal. But it is advisable to keep this variation within the limits of ¼ in.

N.B. These measurements must be made on a straight and level road.

(*h*) Height between the centres of the buffer-rams and the top

of the rail, when empty, to be a maximum of 3 ft 6 in. and a minimum of 3 ft $3\frac{1}{2}$ in.

(*i*) Height of wagon from the rail-level to the top of the body to be not more than 10 ft at the sides and 11 ft 6 in. in the middle of the ends.

STRIPPING PREPARATORY TO REBUILDING

If the wagon body is in good condition and only minor repairs are required, the following procedure can be applied—

1. Remove all knee-feet bolts.
2. Release the end-pillars from the head-stock and corner-plate bolts which are fitted through the side-rail.
3. With the aid of a screw-jack or other suitable appliances, lift the body clear of the frame and pack in position.
4. Run the frame clear of the body. This can now be stripped with freedom of movement.

Should the body require extensive repairs, it is advisable to remove the body in sections and place it neatly round the repairing site.

To be clean and methodical in all activities is an important asset.

Stripping the Frame. The method used depends on the frame-timbers to be renewed—

1. If the renewals required are two sole-bars—

(*a*) Remove draw-bar pins, spring-blocks, and buffer-rams.
(*b*) Strip all bolts and nuts, etc., from the underside of the frame before removing the wheels and placing the frame on trestles.

2. If the renewals required are one sole-bar and three cross-members—

(*a*) Dismantle the frame completely.
(*b*) Remove the wheels, etc.
(*c*) Rebuild on trestles.

MARKING OUT WAGON-FRAME MEMBERS

When reading the detailed description of the marking-out of frame-members for a rebuild wagon, the reader will doubtless observe a similarity between these details and those given in Chapter V on Repairing Wagons. This cannot be avoided, however, without breaking the continuity of either of the two subjects.

For the purpose of clarification, the difference between the two subjects may be stated as follows—

1. To *rebuild* a wagon is to alter the construction from the 1887 Specification to the 1907 Specification and subsequent addenda, and involves a major alteration to the frame components.

2. To *repair* a wagon is to renew a defective member, or members, in accordance with the Specification to which the wagon was built.

Thus it is obvious that, although constructional details are similar, it is not practical to include both subjects in the same chapter. Usually a workman marks out the frame-members for boring and shaping according to his own method of construction. One method is to mark the frame-members out in the following sequence: middle-bearers, head-stocks, middle-longitudes, sole-bars, and end-longitudes.

The reason for marking middle-bearers and head-stocks first is that the details on these members are quite simple, and verification by calculation is not required. Also after the machining of these members the workman has a considerable amount of skilled hand-tool work to do on them before they can be fitted, and during this time it is possible to proceed with the machining of the sole-bar, thus ensuring continuity of production.

The spacing of tenons and bolt-hole centres is to be measured from the top face of the frame timbers.

Marking Out the Middle-bearers

1. Centre the timber and square a line round all faces, marking one face as the top face.

2. Commencing from the centre-line on the middle-longitude side (inside face), measure the spacing and thickness of the middle-longitudes (usually 10 in.) and the tenon shoulder-length of the bearer (6 ft 1 in. or 3 ft $0\frac{1}{2}$ in. either side of the centre-line).

3. Add to this the tenon-length of $1\frac{1}{2}$ in. and square all marks across the face of the bearer.

4. Measure:

(*a*) The spacing of mortises in the sole-bar for the bearer tenons.

(*b*) The spacing of middle-longitude tenons and mark on the bearers.

5. Continue the shoulder-lines on the top face of the middle-bearer, and from these mark the position of side knee-feet bolt-holes (as detailed for end knee-feet bolt-holes, obtained by the same procedure).

6. Continue the tenon shoulder-lines from the top face down the head-stock side (front face) of the bearer and square across the bearer the outline of the tenon from the other side.

7. Measure from the shoulder-lines, the centre-line of the brake-brackets, $6\frac{3}{4}$ in., and mark the centres of brake-bracket bolt-holes.

8. From the brake-bracket centre-line, mark the centres of the brake push-rod carrier bolt-holes, which are obtained from the brake push-rod carriers.

9. From the centre-line of the middle-bearer, measure and mark the spacing between the end-longitudes, usually 9 in.

10. Obtain the thickness of the end-longitudes and diagonals, and, measuring from the longitude spacing-line, mark and square these lines across the face of the bearer.

11. Obtain the spacing of longitude and diagonal tenons, and mark between these lines.

12. On the centre-line of the middle-bearer, mark the position of the intermediate draw-bar hole—6 in. from the top face, $2\frac{1}{8}$ in. diameter hole.

N.B. (*a*) Mortises should be $\frac{1}{16}$ in. deeper than the length of the tenons, and the mortises for securing the under-beds should be the same depth as the protrusion of the under-bed.

(*b*) The position of the diagonal tie-rod centres are determined by the position of the side-rail cross-rods and end pillar-centres. The applicable drawings show the diagonal tie-rod holes to be 2 ft 9 in. centres, and $2\frac{1}{2}$ in. from the top face of the middle-bearer.

Marking-out of Head-stock

1. Calculate the length of the head-stock, plane, cut to length, obtain the centre, and square this line round all faces.

2. From the centre-line on the inside face of the head-stock mark with the square the spacing of end-longitudes, 9 in., and from these lines mark the thickness of end-longitudes, usually $3\frac{1}{2}$ in.

3. From the centre-lines mark the width of the frame between the sole-bars, 3 ft $0\frac{1}{2}$ in., and also the thickness of the sole-bars.

4. From the inside of the sole-bar line measure the spacing of the diagonal from the sole-bar, obtained from diagonal-knees and usually 6 in. or $6\frac{1}{2}$ in.; also mark the thickness of the diagonals.

5. Having marked the position of frame-members, measure the spacing of the tenons on the diagonals, longitudes, and sole-bars, and mark between these lines.

6. Mark the position of the short strap-bolts, $\frac{1}{2}$ in. from the outside face of the sole-bar line.

N.B. Strap-bolts centres are obtained from the buffer-guides.

7. Mark out on the top face of the head-stock the position of the end-door knee-feet bolt-holes, continue the inside sole-bar line across this face of the head-stock, and, measuring from this line towards the end of the head-stock, mark the thickness of the sole-bar and side-rail, excluding rebate, if any.

N.B. If the wagon is one with spaced side-rails, mark the thickness of packings 1½ in. and thickness of side-rail 4 in., thus marking on the top face of the head-stock the overall width of the wagon-body to the outside face of the sides.

8. To obtain the centres of knee-feet bolt-holes from the end-door knees fastened to the wagon-body, measure from the face of the sides to the centre of the bolt-holes. The measurement obtained can now be transferred to the top face of the head-stock, measuring from the lines positioning the wagon-body.

N.B. If the end-door knees are stripped from the wagon-body, measure from the face side of the knee and add to this measurement the thickness of the side.

9. An alternative method of obtaining the position of the end-door knee-feet bolt-holes is to find the length of the end-door planks and add ½ in. for clearance gap; add also the thickness of both sides; halve the measurement obtained and, measuring from the centre-line of the head-stock, mark the width of body to the outside faces, thus positioning the outside faces of the wagon-body on the top face of the head-stock. Obtain the bolt-holes in the end-door knees, as detailed in paragraph 8.

10. Mark head-stock hooping-lines, usually 2 in. from the end of the head-stock.

11. Turn the head-stock over to the front face and on the centre-line draw a horizontal line 6½ in. from the top face of the head-stock. From these centre-lines, equally spaced, measure the draw-bar mortise hole 3¼ × 2¼ in.

12. Use the face-plate as a template to mark out the bolt- and rod-holes.

13. The centres of the rods are the same as marked on the middle-bearer.

14. Measure the end-pillar washer-strap for rod- and bolt-hole centres.

Buffer-centres

1. Measuring from the centre-line, mark the buffer-centres 2 ft 10¼ in. × 2 = 5 ft 8½ in.

2. Mark the centre of the buffer-holes 6 in. from the top face.

N.B. The buffer-centres are 5 ft 8½ in.

3. Measure the buffer-guide for the centres of the bolt-holes and mark on the head-stock.

The head-stock is now ready for machining. When preparing, the following points should be noted—

1. Make clean, straight mortises.

2. The half-mortise for end-longitudes and diagonal-underbeds should be the same depth throughout.

3. The diagonal-mortise should be at the same angle as that formed by the diagonal in the frame.

4. When hooping the head-stock, saw along the lines already marked to a depth of ½ in. Examine the hoop. It will be found that one side is slightly enlarged. Press this side to the head-stock, and with pencil mark round the inside of the hoop. Shape to these lines, leaving the bottom line in by $\frac{3}{32}$ in.

5. Plane all faces level and chamfer. Fit on the hoop.

Marking Out the Sole-bar. If only one sole-bar is to be fitted, care must be taken when measuring the sole-bar which is not to be renewed—

1. Measure this sole-bar to find the centre, and mark round all faces.

N.B. The wheel-base and the space between the middle-bearer mortises should be equal measurements on either side of this centre-line.

2. Measure from the centre-line the length to the tenon-shoulders.

3. If the length, wheel-base, and the space between middle-bearers are correct, mark out the new sole-bar to correspond.

As it is often necessary to renew a sole-bar, the good sole-bar may have been measured and fitted incorrectly; if this is the case it is often possible to rectify these faults. To illustrate—

A wagon of 15 ft length with 5½ in. thick head-stocks (which means sole-bar tenon shoulder-length will be 14 ft 1 in.).

1. If the remaining sole-bar is too long, this can be adjusted by recutting the shoulders to the correct length and shortening the tenons.

2. If the sole-bar is too short, this can be rectified by—

(*a*) fitting head-stocks, 6 in. thick; or

(*b*) shortening the body; or

(*c*) fitting a new sole-bar.

3. If the wheel-base centres are not at an equal distance from the sole-bar centre-line, as R.C.H. Regulations do not allow the

plugging of axle-guard bolt-holes, the new sole-bar would have to be marked out to correspond, providing the differences were small. The correct method, however, is to scrap a sole-bar which has a wheel-base that is not at equal distance from the sole-bar centre-line.

4. If the space between middle-bearer mortises is not an equal distance from the sole-bar centre-line, the mortises can be plugged and recut.

N.B. The importance of the correctness of the wheel-base must be appreciated. If the wheels are to run true, they must be an equal distance from the sole-bar centre-line both longitudinally and diagonally. Wheel-base centres, longitudinally, are usually 9 ft 0 in. or 4 ft 6 in. either side of the sole-bar centre-line.

If, as occasionally occurs, the good remaining sole-bar has been marked out incorrectly, providing the fault is not too serious, the wheel-base on the new sole-bar could be made to correspond, e.g.

wheel-base on good remaining sole-bar;
4 ft 6 in. right-hand of centre-line;
4 ft 5½ in. left-hand of centre-line.

In this case the new sole-bar would have to be marked out to those measurements, otherwise the axle-guards would be out of square. There are some workmen who under such circumstances would insist that the correct method is to make the wheel-base on the new sole-bar 9 ft 0 in., regardless of the ½ in. narrower wheel-base on the remaining sole-bar. It is correct to repair or rebuild a wagon to the Specification, but it is incorrect to make the wheel-base wider at one side than at the other, assuming, of course, that to obtain squareness of axle-guards the frame has been cramped out of square.

The result of such a procedure would be that both wheels would be running out of true alinement, with consequent hot bearings. This method, however, cannot pass inspection if the axle-guards are squared longitudinally as well as diagonally from the centre-line.

5. Any other defects due to faulty marking-out on the remaining sole-bar can be rectified by plugging and reboring, or, in the case of ironwork, replacement. If, however, the sole-bar is bowed more than 1 in., it is advisable to replace by a new one.

To mark out axle-guard bolt-holes—

(*a*) Draw a line horizontally 2⅛ in. from the bottom edge of the sole-bar, about 1 ft 9 in. either side of the wheel-base line.

(*b*) Square two lines 4 9/16 in. either side of the wheel-base line

and place the flat face of the axle-guard on the sole-bar, the legs touching the lines marked and the bottom crown-holes centred with the horizontal line.

(*c*) With the haft of the square pressed to the bottom face of the sole-bar, adjust the outside leg of the axle-guard until it is in alinement with the blade of the square and, using the axle-guard as a template, mark the position of the bolt-holes.

ERECTION AND SQUARING

After all frame timbers have been prepared, the frame can be built, all joints painted, and all ironwork bolted on. It is essential that the frame should be levelled accurately; centre-pop the wheel-base lines, marked on the top face of the sole-bar and in the centre of the sole-bar top face, using a trammel, square the frame diagonally. If the frame should be out of square, loosen frame-rods and, using a frame-cramp, rack the frame dead square and screw up all rods.

The frame can now be completed, tested, and checked to see that it complies in every detail with the 1911 specification and addenda. The following points should be watched—

1. Width of frame between sole-bars 6 ft 1 in. (no variation on this measurement is allowed).
2. Bearing-spring shoe-centres, 3 ft 6 in. and 6 ft 6 in.
3. Buffer-centres, 5 ft $8\frac{1}{2}$ in.
4. Wheel-base centres on both sole-bars should be identical.
5. Measure length of wagon over head-stocks at both sides of the wagon-frame; it should be the same on each side.
6. Test the axle-guards longitudinally from the sole-bar centre-line: both sides should be identical and the axle-guards fixed square.
7. Test the axle-guards diagonally to the outside legs at the top and bottom.

N.B.

(*a*) Variation allowed from dead square is $\frac{1}{4}$ in.

(*b*) The true squaring of a wagon-frame cannot be achieved unless the frame has been correctly levelled.

(*c*) Care must be taken in the shaping of tenons and mortises. These must be finished square, and tenons must be $\frac{1}{16}$ in. less in length than the depth of mortise holes.

Side-rails could be marked out at the same time as sole-bars were marked; otherwise refer to the paragraph dealing with side-rails (pp. 42, 74).

Fitting the Body to the Wagon-frame

1. Fit in position the fast-end sill. The wagon-frame is now ready to be wheeled. When this is completed, place the frame in position to fit the body, which can be lowered into position and secured there.

2. Fit in the floor of the wagon and complete the various small details that are straightforward operations.

3. If the body was dismantled, fit in position the side- and end-knees and the floor of the wagon. Erect the fast end; when securely fastened, fit the sides of the wagon, then side-doors and end-door.

4. If the body is completely new, refer to Chapter III.

5. When fitting the body of the wagon, the rail-track should be level. If it is not, level the wagon-frame before fastening the body.

N.B. The normal rebuilding details have been covered. It is appreciated, however, that wagons due for rebuilding were built thirty to sixty years ago, and although they look similar they are different in constructional detail. The points covered, however, are applicable to wood-framed wagons built to the 1887 specification.

CHAPTER VIII

STEEL WAGON CONSTRUCTION AND REPAIR

ESSENTIAL principles—Erection of riveted steel frames—Fabricated steel wagons—Welded wagon construction—Standard steel wagon-frame, 9414—Steel wagon-frame rebuilding—The repairing of steel-frame and all-steel wagons—20-ton all-steel hopper wagons

ESSENTIAL PRINCIPLES

THE building of steel-frame and steel mineral wagons clearly emphasizes the comprehensive knowledge of certain subjects which is required by apprentices. These subjects may be classified as follows—

(*a*) The care and use of hand machine-tools.
(*b*) The constructional designs of all types of steel wagons.
(*c*) The practical principles of—
  (i) The marking-out of joints.
  (ii) The various methods of erection.
  (iii) The use of jigs.
  (iv) The fabrication of parts.
  (v) The methods of securing joints, e.g. bolts, rivets, or electrical welding.

Taking these subjects in their respective order—

(*a*) *The Care and Use of Hand Machine-tools.* This has been fully explained in Chapter I.

(*b*) *The Constructional Designs of All Types of Steel Wagons.* Steel wagon-frames are designed to meet the specific purpose for which the wagon is required, but R.C.H. Drawings (1944) Nos. 1400–5 give the constructional details of the standard steel-frame wagon with a wooden body and floor, and also the all-steel wagons which, although they have a larger carrying-capacity, can be said to conform to the same principles of design. In addition to these, there are various types of other wagons, e.g. all-steel hopper wagons, whose frames are constructed with a view to seating the hopper; and various methods of locking or unlocking the bottom-doors. These types and methods are numerous, but they are all approved by R.C.H. and therefore should be understood in all their details.

(*c*) *Practical Principles.* When repairing or building steel-frame wagons the following three points are essential to the obtaining of a good solid joint—

FIG. 41. STANDARD 13-TON STEEL-FRAME WAGON (1943)

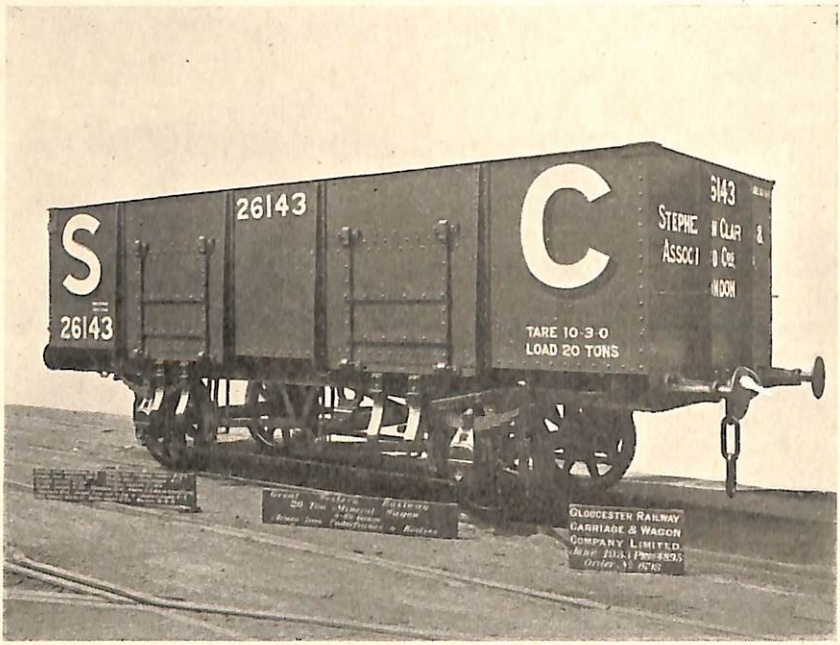


FIG. 42. G.W.R. 20-TON MINERAL WAGON (1933)

(i) Accuracy in the marking-out of the steel frame-members.
(ii) Accurate machining.
(iii) Careful fitting of the parts comprising the joint.

If these factors are neglected, the probability is that they will be the cause of numerous difficulties in the erection of the wagon-frame. In addition to these three essentials, the following points should be noted in connexion with rivets—

(i) They should have an efficient pull on the parts to be riveted.

(ii) The rivet-head should be properly formed, and should fit squarely to the parts being secured.

Marking-out. The principles explained for the marking-out of wood frame-members must still be applied. The worker will find the following four articles invaluable—

(i) Steel tape for obtaining lengths and centres.
(ii) Steel pocket-rule for measurements under 2 ft.
(iii) Steel scriber for marking steel parts.
(iv) Adjustable gauge used in conjunction with scriber.

Marking Out Sole-bars, Head-stocks, and Cross-bearers.

1. The marking-out of these members should be commenced by obtaining the dead centre of the individual member and from this centre-line measuring the lengths, widths, and centres of the various wagon parts to be fitted to, or in conjunction with, the member being marked out.

2. When marking out the position of jointing-angles, allow $\frac{1}{16}$ in. draw to ensure a tight and solid joint; for example, in the fixing of the sole-bar and head-stock jointing-angle; the rivet-holes marked on the head-stock to accommodate the knee-iron must be accurate, or else the width between the sole-bars will be affected. On the sole-bar side of the knee, however, the rivet-holes should be set back $\frac{1}{16}$ in. and the knee riveted to the sole-bar joint first thus ensuring a good joint.

3. Cross-bearer and sole-bar jointing-irons to be riveted to the cross-bearer first.

4. Jointing-irons to be riveted to longitudes and diagonals previous to the erection of the frame as a complete unit.

ERECTION OF RIVETED STEEL FRAMES

The method of erecting a steel frame will, of course, vary in accordance with the facilities available, but the following method is generally adopted when mechanical equipment is not available—

1. Rivet wagon parts and jointing-angles into position.

2. Place the sole-bars in position, the width between them to be 6 ft 3 in. and the sole-bars to be level.

3. Fit the head-stocks on to the sole-bars, and bolt into position.

4. Using a spirit-level, test these members and square the frame diagonally from corner to corner. If the frame is not true, loosen the bolts which fasten the head-stock to the sole-bars and move the sole-bars into the required position.

5. Fit the cross-bearers between the sole-bars and bolt into position.

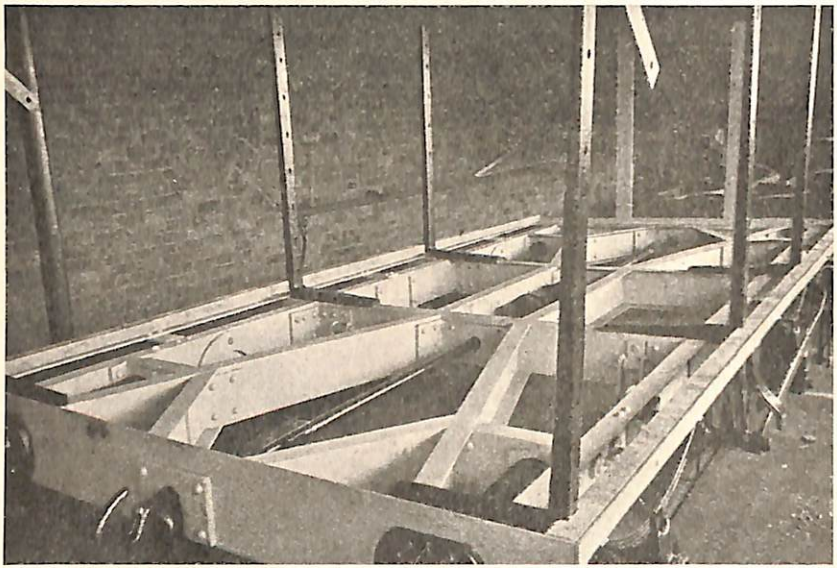


FIG. 43. METAL UNDERFRAME

6. Fit the middle-longitudes between the cross-bearers and bolt into position.

7. Screw up all bolts and check the squareness of the frame. If any deviation is found, it should be rectified immediately.

8. Rivet together the middle section of the frame.

9. Remove the head-stocks and rivet the longitudes and diagonals into position.

10. Refit the head-stocks and bolt into position.

11. Check the frame for squareness and for correct width between the sole-bars.

12. Rivet the head-stock to the other members.

If the frame-members have been marked out carefully and joints fitted and holes drilled accurately, there should be no

difficulty in the fitting and riveting of the frame. If, however, during the bolting together of wagon-frame parts, the frame has a tendency to move out of a square position, the cause must be found and rectified immediately. The probable causes of this fault are—

1. Sole-bars and cross-bearers being of unequal length.
2. Head-stock rivet-holes drilled in an incorrect position.
3. Jointing-angles not being formed at a true angle of 90°.
4. Joints not being perfectly shaped to a square position.
5. Jointing-angle rivet-holes not drilled to the correct position.

FABRICATED STEEL WAGONS

To fabricate is to join prefabricated units into a whole. That is precisely the principle of wagon construction by methods of fabrication. To illustrate: the ordinary method of building steel wagon-frames together is by a process of bolting component parts to the sole-bars and head-stocks, testing the square position of the frame as erection proceeds, thus forming the components into units bolted together; then unbolting the frame in the form of segments and riveting these together, and eventually replacing the segments and riveting *these* together, thus completing the building of the wagon-frame.

N.B. Actually the sole-bars and head-stocks take over the functions of a jig.

The Erection of Steel Wagons by a Process of Constructional Stages. It is necessary to divide up the productive method of prefabricating components into parts, and fabricating parts into a whole, otherwise a production line based on stages of erection would be difficult to operate. The feasible limit to this method of productivity is imposed by the facilities available.

It will readily be understood that shop facilities and experience vary considerably, resulting in various methods of production practised in different workshops of the wagon-building industry. The general principle is to prepare large units by a process of production similar to one of the following two methods—

METHOD I

1. Wagon-frame members are shaped and drilled in bulk quantities. All operations are executed by mechanized tools, and marking-out and fitting of members to each other is eliminated.

2. The prepared components are prefabricated in suitable jigs into units of the wagon-frame, these units being then fabricated in a frame jig to complete the process of fabricating the wagon-frame, the steel floor being either riveted or welded to the frame.

3. The sides and ends of the wagon-body are prepared in jigs; these units are then joined together by riveting, and the completed body is ready for being completely riveted to the wagon-frame. Doors, brakes and buffer-units are fixed in position, and the wagon only requires painting to finish the process of building.

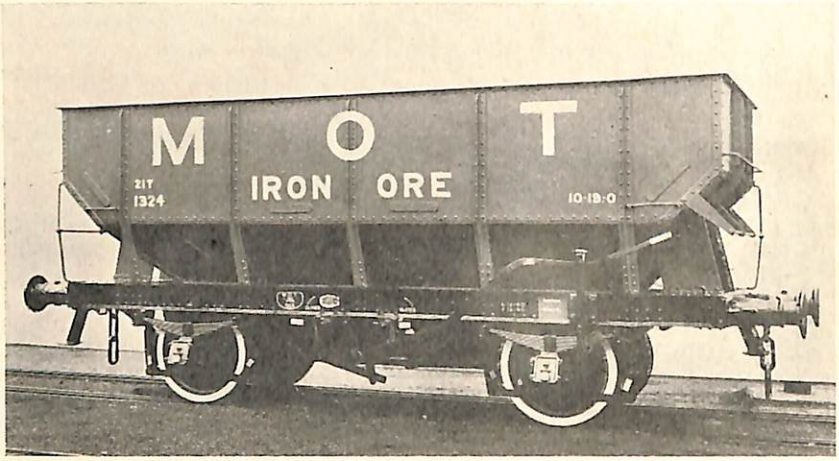


FIG. 44. GLOUCESTER 20-TON IRON-ORE HOPPER WAGON (1940)

METHOD II

The wagon-frame is produced as for the first method.

1. The completed frame, with the floor fastened in position, is placed at the bottom of the production line. The fast end is riveted to the frame, then the two sides and the end-door bridge are bolted together.
2. Second stage welding or riveting of body is completed.
3. Fitting of side- and end-doors.
4. Wheels fitted.
5. Bottom-doors fitted.
6. Brakes, draw-gear, and buffer-units fitted.
7. Wagon painted.

This completes the cycle of productive stages for building wagons by methods of fabrication.

There is opportunity for the apprentice to introduce new ideas in the field of fabricating wagon components and in the various stages of production and design.

WELDED WAGON CONSTRUCTION

The potentialities of "Arc-welding" in the wagon industry were visualized several years ago, but mainly as an asset in repair

work. The post-war demand for a large quantity of rolling stock has, however, opened up new fields for this technique and arc-welding has come to be recognized as the medium to produce large numbers of railway wagons constructed by stage assembly line methods. This development of arc-welding in the wagon industry has been hastened by the progress made in the efficiency of mechanical aids, which are at the service of the manufacturer.

Arc-welding. The theory and practice of welding is far too extensive a subject to be dealt with in this book. However, for the benefit of the wagon engineer who is not familiar with welding technique, a brief survey of the salient features is given in this chapter.

The aim and purpose of welding is to heat locally the members of a structure to a temperature at which melting occurs. This creates a liquid metal pool and results in the fusion of metals without the application of pressure. The pool of metal in the cooling process forms a single line of metal termed weld metal.

The common methods used for generating a welding arc are—

1. Metallic arc-welding with a.c. or d.c. power.
2. Carbon arc-welding generally with d.c. power.
3. Atomic hydrogen welding with a.c. power and hydrogen gas.

The main features of the three types are—

(*a*) Fusion of metals is achieved by use of an electrode connected to the positive line of electrical energy. Thus the electrode serves the dual purpose of feeding metal to the molten pool and conveying the positive charge of electricity for the arc. The negative charge is passed to the arc through the members being welded.

(*b*) This differs from (*a*) in that the electrode is carbon and fulfils one object—to carry the negative charge to the arc. The positive charge is passed through the members being welded. If additional metal is required for the fusion a "filler" is used, independent of the electrical circuit.

(*c*) Fusion of metals by this process is achieved by the use of two tungsten electrodes embedded in the design of torch. The ends of these electrodes carry the positive and negative charges and are adjusted to form the arc. When the arc is formed, hydrogen gas is forced under pressure into the arc.

The first method, metallic arc-welding, is the process usually adopted for the building of steel rolling stock. In this process the generation of heat is achieved by the passing of electrical energy in two planned directions—negative (earth) and positive (to hand), the earth terminal being connected to the work-piece

and the positive terminal to the electrode. When the tip of the positively charged electrode is applied to the negatively charged work-piece, the circuit is completed, the arc being created by the act of withdrawing the electrode from the work-piece about $\frac{1}{8}$ in. or more, whereby the arc becomes a small electric furnace, providing maximum heating of the metal. This intense localized heat creates immediately a molten pool of metal in the metal joint to be welded, the core of the electrode melts, thus supplying molten feeder metal to the molten pool, the marriage of metals welds the joint into a whole. The operator, by hand-manipulating the electrode, can control the speed and direction of the weld.

N.B. Bare electrodes are generally attached to the negative pole.

Electrodes. In the early application of welding, direct current was the form of electrical energy used and bare wire corresponding to the nature of the metal to be welded, with flux of separate medium, was used for electrodes. Modern electrodes are covered with a coating of flux. This keeps the rods from contamination and forms a flux which prevents the oxidization of the molten pool.

Operators. If a high standard of welding is to be achieved it is essential that the operator has full knowledge of the practical and theoretical details of the operation. It must also be realized that the technique varies widely in different types of work, and a welder may be highly skilled at one type of operation but may require further coaching before undertaking a new type of work. The operators have to be provided with facilities for gaining up-to-date knowledge of welding technique, in order to regard themselves as skilled craftsmen and maintain a pride in their work.

A first-class welder must be capable of reading a drawing and be familiar with all welding symbols. He must be fully conversant with the nature and composition of the parts to be welded. A working knowledge of electrodes and the welding equipment, both in operation and maintenance, is necessary.

In the operation of the electrode a high standard of manual dexterity is needed in the striking and breaking of the arc, to avoid slag trap, and the consequent movement of the arc. The welder must be constantly alert, watching the oscillations of the arc and the flow of molten metals in the pool. It must be realized that variations in the length of arc, or a clumsy weaving motion may result in lack of penetration. Usually, faults occur when the arc is struck or broken.

Procedure. The first step in the achievement of an efficient welded structure comes before the welding process commences. It is the accurate fitting together of parts, of or components either

with or without the aid of "jigs." An accurate mating will increase the strength of the weld. A bad original joint means an increase in the welding time and extra filling from the electrode, both of which are wasteful and not conducive to a good, strongly welded joint.

The welding foreman must have a thorough knowledge of the strength required in the joints and the stresses they will undergo. These factors govern the type of electrode to be used at machine setting, and the penetration to be achieved. Test pieces of the same metal should be welded and tested to the destructive pitch. The following points should be discussed by the foreman and the welders—

1. The size and penetration of the weld required at the joint. These determine the size of electrode to be used and the amperage setting of the welding machine.

2. The strength and stress required for the joints in the structure. These govern the position of the welds and the number of runs required.

As a rule, the welding operator commences at the centre of the structure and works outwards. A study of constructional design of the structure will result in a welding plan which divides the stresses created by the solidification of the molten metal equally throughout the structure.

A welding plan embodying full details of the type of electrodes, number of weld runs and the strength of each joint, and all other information relevant to the purpose and plan of the structure should be available to the welding operator.

The weld should be smooth and free from marked irregularities. A low welding temperature will result in the formation of slag pockets in the form of blisters, causing an inferior joint, which may require cutting out and re-welding. The removal of the slag from the weld is also an indication of the quality of the weld. Difficulty in removing generally indicates that the operation was performed on too low a temperature, with resultant poor penetration.

The cooling off of the molten metals causes contraction of structural parts and thus some distortion to the structure unless efficient clamping and presetting devices are embodied in the jig.

Assembly Jigs When the various components have been prepared in the drilling, or shaping, machines, they are ready for transfer to the assembly jigs where various parts are prefabricated into units, and the units fabricated into a whole structure. A detailed study of the plans of the structure must be made in

order to achieve a balanced production. If, for example, the machining of parts is a shorter process than the assembly in the jigs, a flood of prepared parts will result, creating a bottle neck. In this case it is an advantage to weld the various components in a series of small jigs which on completion can then be transferred to the main assembly jig for final erection. Another vital consideration in the design of the assembly jig is the required positions, strengths, and lengths of the various welds. Careful thought must be given to ensure that a jig is designed which combines accessibility for the welder with a maximum penetration and fusion of the welded joints.

The first jig on the assembly line is the setting-up and tack-welding jig. In this jig the prepared parts are first positioned and tack-welded together. Location is the first important detail of this jig, a speedy effective means of locating the components in relation to each other and no recourse to measuring are essential. This location is ensured by a system of locating stops built into the jig. These must be so employed that they ensure dead accuracy in the positioning of the parts and are simple in operation, so that the structure may be quickly removed from the jig after welding.

The components, having been positioned to the locating stops, are held to that position by clamping tools, of which various types are used—tapered dowels, wedges, screw and lever operated clamps. These are all used to hold the parts rigidly in the assembly jigs. The aim is a maximum simplicity of operation and any over-complicated device should be avoided. Two points must be watched when deciding on the type and position of clamp to be employed. Firstly the clamp must not be an obstacle to the welder and must facilitate the removal of the structure when the welding operation is completed. The other feature of design to be constantly borne in mind is the danger of "weld splatter" on the parts in the jig. The direction of the weld must be studied and if necessary shields be provided to avoid weld splatter on the structure. The weight and strength of the jig must be in relation to the work it has to do, but anything cumbersome must be avoided.

The next jig on the assembly line is the weld-positioning jig. This jig must provide a means of rotating the structure when fixed in the jig so that the welding operations can be performed in the most favourable position.

The most simple type of rotary jig has the frame rotating on a central axis. The jig is constructed with the usual locating stops and clamping devices. This is then pivoted round an axle, the

ends of which protrude from the jig. These ends are supported on trestles and the whole jig can be rotated to any desired position. This two-point suspension jig is simple in construction and operation, and efficient in use when the majority of the welding operations can be carried out in a few planes.

A more complicated type of rotary jig is needed for some types of structures, but the principle of the two-point suspension jig is used, i.e. a frame is built round the jig. The jig can be rotated in this frame in one plane and the frame is again pivoted on another axle or trunnions rotating in the other planes. Where structures are large similar to wagon-frames, axles are fitted directly to each end of the wagon-frame; then this structure is placed on positioning stools, enabling two-plane welding to be carried out. There are also many types of mechanically controlled positioning tables.

In operation, the jig with many advantages is a combination of the fixed jig and the rotary jig. This jig enables the welder to position and tack-weld parts together, and to proceed immediately to pre-stress the structure and then weld together the structure. This ensures that one operator completes the whole process and no time is lost by waiting for a slower operation, and only one welding machine or unit is in use. Further, the welder is aware that the complete process rests with him and will exercise more care in ensuring that the setting-up and tack-welding processes are accurately executed.

In general, two features of the arc-welding process must be remembered in the design and construction of the assembly jigs. The first is the stress created by the contraction of the weld metal during solidification. This will cause the distortion of the structure unless care is taken to allow for this in the setting-up process. This process is carried out after the various components have been tack-welded, the structure being forced by clamps, wedges, and packings placed at selected points on the jig.

The second feature is the necessity for a close and accurate mating of the parts of the structure. Otherwise the extended joints cannot be penetrated on the first run by the welder and consequent runs may cause slag traps, and cracking of the weld.

Finally all jigs must be accurate and of robust construction, as they will be roughly handled by the setters up. Continual and thorough maintenance of the jigs and fittings pay a good return.

Production Stages of Welded Wagons. Individual wagon-works employ methods of stage production and assembly according to their own experience and workshop practice. Here is a

general outline of the various methods practised in the fabrication of welded wagons—

(*a*) Sides, ends, side-door, and bottom doors, are fabricated in jigs designed for these parts, and seperated entirely from the main assembly line, When completed, they are ready for attaching to the wagon.

(*b*) Main assembly line, in the following stages—

1. Wagon-frame parts are loaded into the frame jig, locators setting each part to its relative correct position in the wagon-frame. The parts are then clamped securely to that position, and after checking the accuracy of the mating of joints, etc., the frame is now ready for tack-welding together. On completion, the frame is unfastened, and the positioning stool trunnions are fitted to each end of the frame. The wagon-frame, now a unit, is lifted out of the jig.

2. The frame is now placed on weld-positioning stools, suspended at both ends by the trunnions which are resting in the stools. The frame can now be rotated to provide the most favourable positions for the completion of welding the frame, which is arranged strictly to a planned welding procedure, commencing from the centre of the frame. On completion, the frame is carried to the floor jig.

3. The frame now requires to be fitted with floor-plates and other accessories. These are arranged accurately on the floor jig. The wagon-frame is now placed top face downwards on the floor-plates, facilities being arranged on the jig to secure the frame and floor plates exactly to the longitudinal and transverse centres of both. The frame is now securely clamped down to the floor-plates, and other components placed in position. The tack-welding of these parts to the frame now proceeds. The frame is now pre-stressed to counteract contraction of longitudinal welds. On completion, the structure is released from the jig.

4. The frame with floor attached is now placed on weld-positioning stools, to enable various accessories to be welded to the frame in the downhand position.

5. The wagon-frame and floor are now placed on stools fastened to the workshop floor for the riveting to the frame of all parts that are fastened by this means. The dimensional accuracy of the erected frame is now checked over, buffer gear is fitted and the interior of the frame painted, advantage being taken of the frame turned over to fit these units.

6. The structure is now placed on fixed stools of minimum height, to enable the body of the wagon to be positioned.

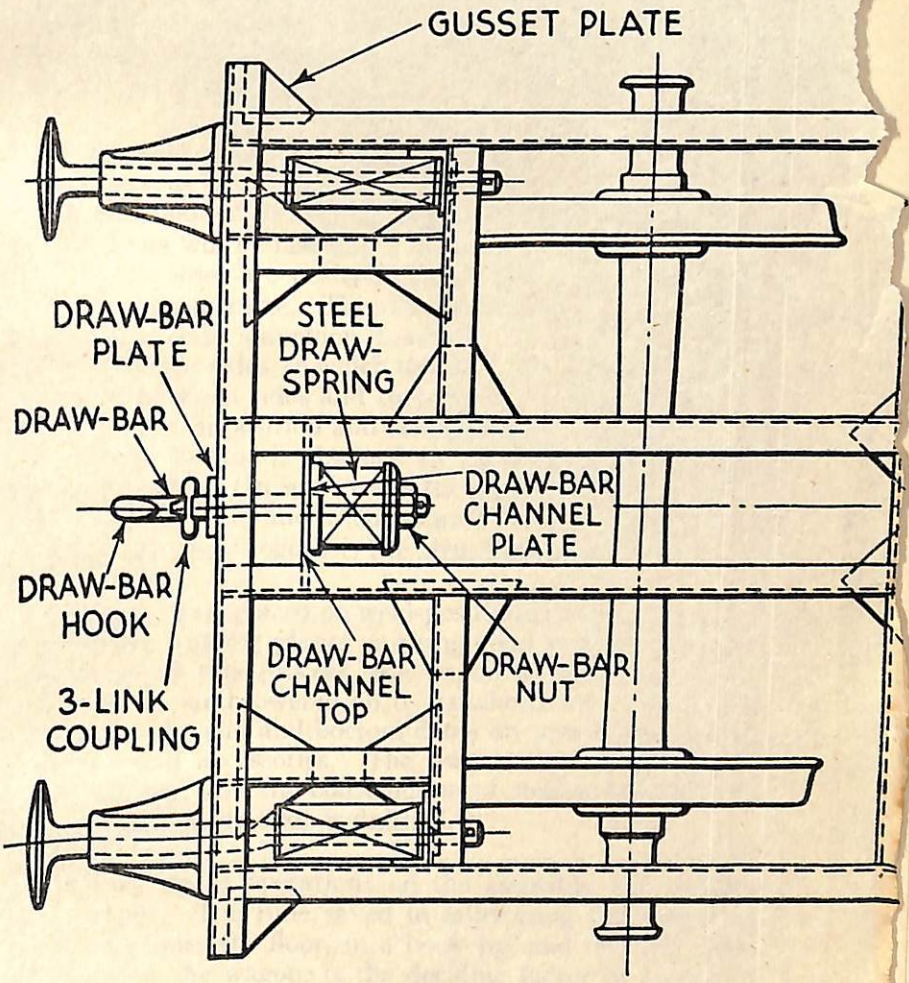

GUSSET PLATE
DRAW-BAR PLATE
STEEL DRAW-SPRING
DRAW-BAR
DRAW-BAR CHANNEL PLATE
DRAW-BAR HOOK
DRAW-BAR CHANNEL TOP
DRAW-BAR NUT
3-LINK COUPLING

FIG. 45.

(T.430)

GUSSET PLATE
STEEL DRAW-SPRING
DRAW-BAR PLATE
DRAW-BAR
DRAW-BAR CHANNEL PLATE
DRAW-BAR HOOK
DRAW-BAR NUT
DRAW-BAR CHANNEL TOP
3-LINK COUPLING

There are two methods of positioning and fixing a body to the frame—

(*a*) The sides, ends, and floor are fabricated in a specially designed jig, which locates each part accurately and strong clamps secure the parts together ready for tack-welding to each other. Since the jig is a weld-positioning jig, it is mechanically rotated as required by the welders. On completion of the welding the wagon-body is released from the jig, and carried to the assembly line, where it is positioned correctly to the wagon-frame, and welded.

(*b*) By this method the wagon-body is fabricated on the wagon-frame and floor in the assembly line.

Two jig side-door frames are bolted in the position in which the wagon side doors will be fastened. These act as side locators and ensure that the sides are positioned correctly to the transverse-centre of the wagon-frame. The sides are placed in position, and clamped to the side stanchion brackets. A built-up frame is erected between the sides, to which the sides are clamped, ensuring correct width between sides and their square position. The fast end is now placed in position and clamped and tack-welded. An end-door bridge locator is fastened to the sides and the bridge clamped in position. (In some cases the end-door and bridge are fastened together first, and then secured to the sides.) After tack-welding the body together, the structure is placed on weld-positioning stools.

7. The wagon, now placed on weld-positioning stools, is rotated to the necessary welding planes ensuring good welding positions. On completion of this process, the wagon is lifted out of the positioning stools, and lowered on to its wheels, etc. Brakework and drawgear, side, end and bottom-doors are now fitted, as well as all other small accessories. The wagon when completed is ready for painting, and the construction of steel-welded wagons by mass production methods is finished.

N.B.

The breaking up of operations on the assembly line ensures increased output. The time saved in fabricating the sides and ends, and sometimes the floor, in a body jig, and erecting these parts directly on the wagon, is the deciding factor in favour of mass-production.

It is anticipated that future welded-wagon design will incorporate a body and floor which can be removed with reasonable ease, and in such circumstances a jig will be provided in which the floor and body can be fabricated, with facilities for weld positioning.

STANDARD STEEL WAGON-FRAME, 1944

The adoption of short independent draw-gear to future steel-frame construction is outlined in R.C.H. Instructions issued 10 January, 1945, Reference Y/P.O./C.L. 123. Metal underframes for wagons have for some time been fitted with short draw-gear and strengthened buffing-springs, the details of which are shown on Drawing No. 214, issued with Y/P.O./C.L. 103. The arrangement and detail of metal underframes with short draw-gear and improved buffing-gear have been available to builders on request, under Drawings Nos. R.C.H. 923–8 (with appropriate suffix letters where modifications have been made subsequent to the original printing).

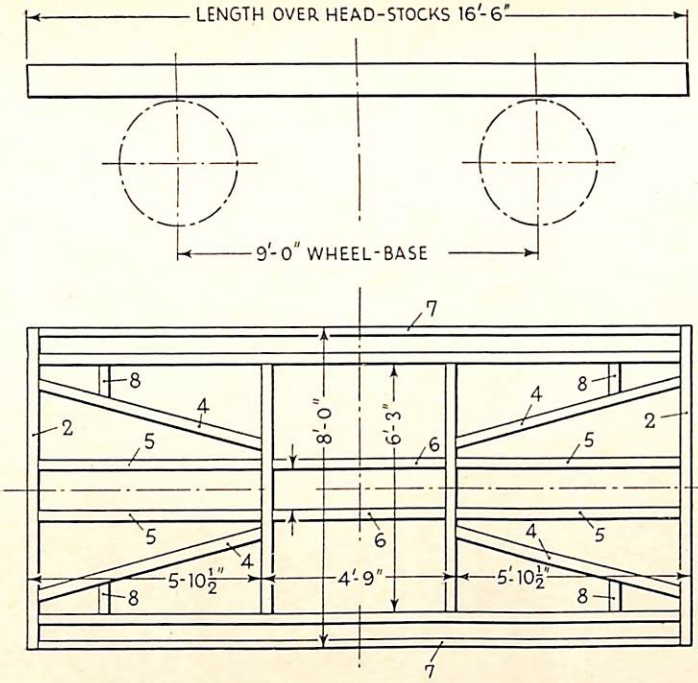
Drawings Nos. 1400–5 inclusive, which relate to 12- and 13-ton metal underframes incorporating the shortened type of draw-gear, are available, and future metal-framed wagons of these capacities must be built in accordance with these drawings (see Fig. 46). Similar arrangements must be followed in respect of metal underframes for 10-, 12-, 14-, and 20-ton tank wagons, 20-ton mineral wagons, and any other metal-frame wagons which may be submitted for approval. In these cases, the appropriate sizes of sections, knees, etc., shown on the respective standard drawings will apply, but will require modification so far as drilling is concerned. The individual details of draw- and buffing-gear are shown on Drawings Nos. 1403–4, although in the case of items on those drawings which are the same in every respect as similar items shown on the existing standard drawings referred to, the existing standard drawings and item numbers (or latest addenda thereto) should be quoted to avoid confusion to manufacturers when placing orders. Drawings specifically applicable to tank wagons and 20-ton mineral wagons will be made available when conditions permit.

The R.C.H. Instruction enumerated above requires numerous alterations to wagon parts, compared with the standard steel wagon-frame, 1923. A survey of the alterations, and of the parts required for the fitting of short draw-gear, which enables the frame directly to absorb the pulling-strain imposed through train movement, will be of interest to those unable to obtain drawings.

To enable a short draw-bar to be accommodated—

(*a*) End-longitudes: $9 \times 3\frac{1}{8} \times 3\frac{1}{8} \times \frac{3}{8}$ in. steel channel are fitted, to the frame, 12 in. apart.

(*b*) At the head-stock end of the end-longitudes a strong knee is riveted which ultimately takes the initial pulling draw-bar strain.



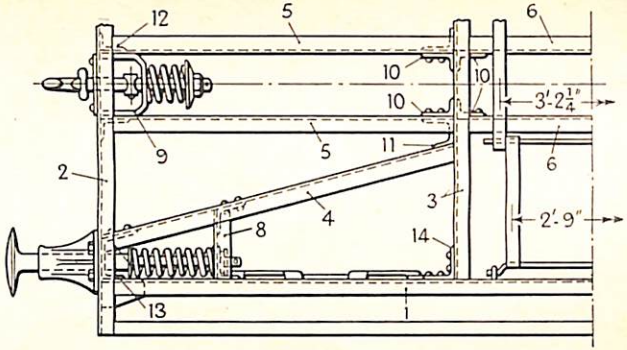


FIG. 46. STANDARD 12- AND 13-TON METAL-FRAME MINERAL WAGON

(Drawings Nos. 1400–05, December, 1944.)

KEY NO.	NO. REQUIRED	DESCRIPTION	MATERIALS
1	2	Sole-bar	M.S. 9″ × 3½″ × 7/16″ channel
2	2	Head-stock	M.S. 9″ × 3½″ × 7/16″ channel
3	2	Cross-bearer	M.S. 9″ × 3½″ × 7/16″ channel
4	4	Diagonal	M.S. 7″ × 3½″ × ⅜″ angle
5	4	End-longitude	M.S. 9″ × 3½″ × 7/16″ channel
6	2	Centre longitude	M.S. 9″ × 3½″ × 7/16″ channel
7	2	Side-rail	M.S. 2½″ × 2½″ × ⅜″ angle
8	4	Trimmer-knee	M.S. 9″ × 3½″ × 7/16″ channel
9	2	Draw-bar knee	M.S. 9″ × 1″ or Grade B iron
10	8	Cross-bar and longitude-knee	M.S. 6″ × 3½″ × ½″ angle
11	4 (R. & L.)	Cross-bar and longitude- and diagonal-knee	M.S. 7¼″ × ⅝″ or graded iron
12	4	Head-stock and longitudinal-knee	M.S. 6″ × 3½″ × ½″ angle B.S.C. A.116
13	4	Sole-bar, head-stock, and diagonal-knee	M.S. 8″ × ⅝″ or Grade B iron
14	4	Sole- and cross-bar knee	M.S. 6″ × 6″ × ½″ N.B.S.E.A.A.

(*c*) Middle-longitudes are spaced 12 in. apart (same as the end-longitudes), thus enabling jointing-plates to be riveted to the bottom flanges of both the middle- and end-longitudes.

(*d*) Diagonals are of angle-section, $7 \times 3\frac{1}{2} \times \frac{3}{8}$ in.

Reference to the R.C.H. Drawings, standard steel frame, 1923 and 1944 design, will give some idea of the alterations necessary to adopt short independent draw-gear.

N.B. The alterations of the width between middle-longitudes affects the bottom-door ironwork.

The parts which are either increased in strength or altered are as follows—

Buffer-units. Self-contained buffers of approved design may be fitted as an alternative to the standard built-in frame buffer-unit. In the latter type of unit, alterations are made to the buffer-ram to accommodate the increased length of the buffer-coil spring; trimmer-knees and angles are adjusted in size to meet this increase in buffer resistance. The Drawing applicable for buffing-gear is R.C.H. 1404.

Draw-gear. The draw-hook overall length is 2 ft 9 in. between the shoulders; centre of the cotter-hole, 1 ft $9\frac{3}{4}$ in.; and the centre of the safety-pin hole from the shoulders of the draw-bar is $7\frac{1}{2}$ in.; diameter of hole, $1\frac{7}{16}$ in.

Safety-pin.

(*a*) Length of pin overall, $3\frac{13}{16}$ in.

(*b*) Diameter of the head, 2 in.

The head is squared on two sides to enable a spanner (width of jaw, $1\frac{5}{8}$ in.) to fit.

(*c*) Thickness of the head, $\frac{1}{2}$ in.

(*d*) Pin-hole to accommodate $\frac{3}{8}$ in. split-pin.

(*e*) The size of collar is: outside diameter, 2 in.; inside diameter, $1\frac{7}{16}$ in. Width of collar, $\frac{1}{2}$ in.

Steel Helical Draw-spring.

Outside diameter, $7\frac{3}{8}$ in.; diameter of hole, $3\frac{7}{8}$ in.

Diameter of coil, $1\frac{3}{4}$ in.

Height of spring home, $6\frac{1}{2}$ in.

Height of spring end of stroke, $6\frac{11}{16}$ in.; load, 13 tons.

Height of spring in position, $7\frac{9}{16}$ in.; load, 2–3 tons.

Spring free, $7\frac{3}{4}$ in. Energy stored in working stroke, 6–7 in.-tons. May be coiled right or left.

Draw-spring Stop.

Draw-spring stop, length, $6\frac{11}{16}$ in.
Draw-spring stop, diameter of hole, $2\frac{1}{16}$ in.
Draw-spring stop, outside diameter, $3\frac{3}{4}$ in.
Made of cast or malleable iron or mild or cast steel.

Steel Helical Buffer-spring.

Outside diameter, $6\frac{5}{8}$ in. max., $6\frac{1}{2}$ in. min.
Diameter of hole, 4 in. max., $3\frac{7}{8}$ in. min.
Diameter of coil, $1\frac{5}{16}$ in.
Height, spring home, $10\frac{3}{4}$ in. max., $10\frac{1}{2}$ in. min.
Height, buffer home, $11\frac{3}{16}$ in.; load, 8 tons.
Height, in position, 1 ft $3\frac{11}{16}$ in.; load, 16 cwt.
Height, free, 1 ft $4\frac{5}{16}$ in. max.; 1 ft $4\frac{1}{16}$ in. min.
Energy stored in working stroke, 19–8 tons.

Buffer-ram. This item is the same overall length as the 1923 standard buffer-ram; but whereas in the 1923 standard the length of 3 in. diameter stem is 2 ft $1\frac{1}{2}$ in., in the 1944 design the 3 in. diameter stem-length of ram is 1 ft $11\frac{13}{16}$ in. This alteration allows for the increased length of the buffer helical springs.

STEEL WAGON-FRAME REBUILDING

The details of construction when rebuilding a steel-frame wagon are the same as described at the beginning of this chapter, but the following exceptions should be noted—

1. Defective rack-plates to be replaced with new rack-plates.
2. If new diagonals are fitted to the wagon-frame, the trimmer-bar must be positioned to accommodate a 14-plate laminated buffer-spring as shown on Drawing No. 14 (reprinted March, 1922), the measurement to be 2 ft 3 in. from the front face of the head-stock to the face of the trimmer-knee (nearest the cross-bearer).
3. Head-stock and diagonal angle-stay to be fitted or refitted; the section to be used $2\frac{1}{2} \times 2\frac{1}{2} \times \frac{3}{8}$ in.
4. Axle-guards to be riveted to the sole-bars.
5. Brake-brackets and vee-irons to be riveted to the wagon-frame.
6. Side-bearing spring-stops to be riveted to the sole-bars, and the increase in length to be determined by the depth of space between the underside of the sole-bar and the bearing-spring shoe face.

7. Floor-planks to be secured in position with wooden side fillets bolted to the quarter-planks.

8. Draw-gear, buffers, brakework, wheels, bearings, springs, and body construction are as detailed for wood wagon-frame rebuilding, with the exception of the buffer-ram and draw-hook, which are shorter in length owing to the difference in thickness between a wood-frame head-stock and a steel head-stock.

THE REPAIRING OF STEEL-FRAME AND ALL-STEEL WAGONS

Diagonal Trimmer-bar ($6 \times 3\frac{1}{2} \times \frac{1}{2}$ in. channel). Steel wagon-frames built prior to February, 1911, were generally fitted with 12-plate laminated buffer-springs, and the diagonal trimmer-bar was positioned to suit the length of the buffer-spring buckle when the spring was in position. Upon the issue of an R.C.H. Instruction that all renewals of laminated buffer-springs must be 14-plate springs to R.C.H. Drawing No. 208A, an alteration had to be made to the position of the trimmer-bar to accommodate the spring.

The R.C.H. Instruction states: "When it is impossible in the case of a metal-frame wagon, built to the 1907 Specification, to replace the 12-plate buffer-spring by a 14-plate buffer-spring without alteration to the underframe, the method of replacing the spring must be in accordance with R.C.H. Drawing No. 557."

The explanation of this drawing is as follows—

(*a*) Enlarge the slot in the trimmer-bar to allow the buffer-spring buckle to pass through.

(*b*) Fit a $\frac{3}{4}$ in. packing-plate at the back of the trimmer-bar, 9×6 in.

(*c*) Fasten the intermediate bar carrier-plate to the packing-plate.

Thus the extra 1 in. in width of the 14-plate buffer-spring buckle, due to the two extra plates fitted in the spring, has been accommodated.

N.B. Wagons built after February, 1911, are designed to accommodate 14-plate buffer-springs.

Sole-bar Strengthening-plates. Where the bottom flanges of sole-bars are weak as a result of corrosion, this defect is repaired by fixing a steel plate to this flange, the width of the flange and $\frac{1}{2}$ in. thick, shaped to fit over the head-stock and sole-bar gusset plates, and securely riveted to the bottom flange of the sole-bar.

If only one sole-bar is defective, then, to maintain the buffer-heights level, packing-plates the same thickness as the strengthening-plate fitted to the opposite sole-bar must be fitted between the bearing-spring shoes and the sole-bar.

Stripping Components Off the Sole-bars

1. Place two lifting screw-jacks under each head-stock, remove bearing-spring shoe-bolts, and lift the side of the wagon until the bearing-springs can be removed.
2. Unfasten and remove bearing-spring shoes, stops, bottom-door fasteners, and gusset-plate rivets.
3. Drill the extra holes required in the sole-bar flange to secure the strengthening-plate solidly to the bottom flange.

Marking Out the Strengthening-plate. There are two methods which can be used as follows—

METHOD I

Using a wood staff the length of the strengthening-plate, place this staff in the position the plate will occupy when fastened to the sole-bar, hold it securely in this position and, using the rivet-holes and drilled holes as a guide, mark on the staff the position of holes. This template can now be used to mark the plate to correspond. It is advisable to number the ends of the template.

METHOD II

Place the plate in position as it will be fixed to the sole-bar. Support it with two blocks of wood placed on the top of the axle-boxes, then lower the screw-jacks until the plate is held rigidly to its correct position. Mark through the holes in the flange of sole-bar the position of rivet- and bolt-holes on the plate.

Fitting in Position

1. Bolt the plate in position.
2. Fasten in position bearing-spring shoes and stops.
3. Fix in position all necessary rivets.
4. Lift the wagon side, replace the bearing-springs, lower the wagon on to the bearing-springs, and fit in position the bottom-door fasteners. This completes the repair to sole-bar.

N.B. All joints to be painted.

Rack-plates. Rack-plates must be renewed in their original form or, as an alternative, can be replaced by two diagonal brace-plates, 5 × ½ in., which must be secured with two rivets to each frame-member crossed by the plate (Fig. 47). Where wagons are fitted with long diagonal strap-plates on the underside of the frame

and large face-plates in place of the ordinary small face-plates, it is not necessary to fit diagonal brace-plates on the top side of the frame.

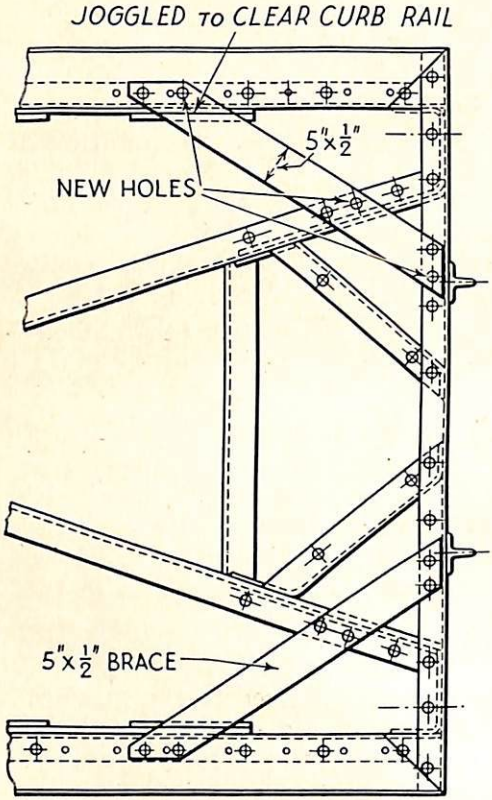


FIG. 47. ARRANGEMENT OF DIAGONAL BRACE-PLATES FOR METAL UNDER FRAMES

Brake-brackets. The positions of the horizontal centres of the brake-brackets are determined by the buffer-centres of the head-stock. Thus, assuming that a 9 in. channel head-stock is fitted, when marking out a new cross-bearer, the section of which is $8 \times 3\frac{1}{2} \times \frac{1}{2}$ in., the centres of the hanger-link bolt-hole formed in the brake-bracket, measuring from the top face of the cross-bearer, should be $4\frac{1}{2}$ in., which will ensure the centre of bracket being in alinement with the buffer-centres, otherwise the position of the brake-block will be affected.

N.B. If a 10 in. head-stock is fitted and the buffer-centres are 5 in. from the top face, the centre of the hanger-link bolt-hole in the bracket must correspond.

Side-rail Fish-plates. When so badly corroded as to be of no further service, these can be replaced with side-rail and sole-bar cleats of $4 \times \frac{1}{2}$ in. section (similar to those fitted to standard wagons).

Fitting of Wood Floor. The usual method employed is to—

1. Fit and bolt in position all side-rail and end-liners.
2. Fit and bolt in position:

(*a*) Side knee-planks.
(*b*) Bottom-door sill-planks.
(*c*) Bottom-door saddle-planks.
(*d*) Bottom-doors.

3. Fit in position the remainder of the floor-planks (it is best)

to fit not thin strips to fill up small gaps, but wider or narrower planks).

4. There are two methods of boring the bolt-holes in the floor-planks.

(*a*) Place each plank in position and wedge the gap; pencil-mark all bolt-holes from the frame; take the planks up and bore holes where marked; replace planks, and bolt in position.

(*b*) Place all planks in position; with the aid of a boring-bit lengthener, bore all bolt-holes, place in position all bolts, and screw these up tightly.

20-TON ALL-STEEL HOPPER WAGONS

Owing to the body of these wagons being to a hopper shape, the "under-doors" have to withstand heavy weights for long periods. This, combined with loading arrangements and the movement of the load when roughly shunted, subjects the under-door fastening-mechanism to load stresses beyond those they were designed to cope with, resulting in strained clutch-bars, levers, and pinions. There are various designs of under-door locking-mechanism in use, operated by lever or screw. The lever type is more economical to produce, but has not the same resistance to load movements as the screw type, which, if all the pinions, screw threads, and housings are well greased and protected from harmful matter, requires very little further attention, unless damaged.

The lever type of door-fastener generally requires adjustments and the locking principle should be understood. Refer to Fig. 48, depicting the locking action of this mechanism, and it will be appreciated how important is the position and set of the clutches, which are welded to the clutch-rod. These are the points of contact which support the door-hinges and door. The clutches must be set to a true horizontal position (90° to the position of the sole-bar) when the slotted lever-arm is fixed in the locking position. The under-door when in position should be in a true horizontal position, and should not in any circumstances dip at the sole-bar side.

If, as frequently occurs, the alinement of the clutches is not horizontal, but tilting downwards, the under-door will be at a lower level at the sole-bar side, and the weight of load on the door in this position has a tendency to thrust the door on to the hinge pivot-pins; these factors combined shorten the length of hinge bearing on the clutches; and, when the door supporting the load is subjected to displacement of load stresses during

shunting operations, the shortness of hinge bearing on the clutches strains the clutch-bar and causes just the fraction of circular movement that allows the end of the hinges to slip free from the clutches, with the consequent spilling of the load on the rail-track.

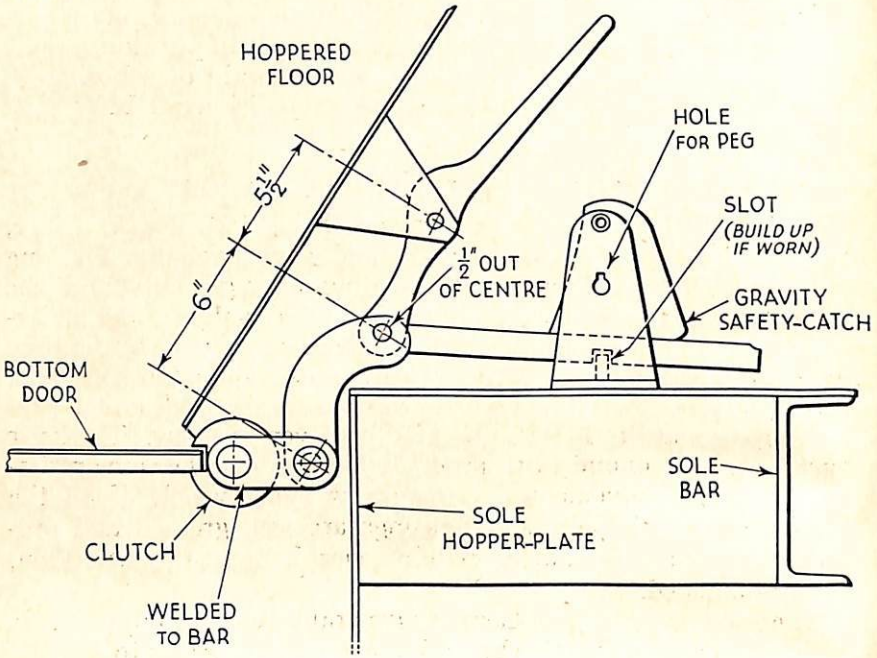


FIG. 48. BOTTOM-DOOR FASTENER

Where the lever-fastener is faulty, the method of adjustment is as follows—

(*a*) If the slot in the locking-bar has become elongated, this defect can be made good by building up the slot with electrical welding and filing to a good fit.

(*b*) The release-handle can be heated and reset.

(*c*) The cantilever connecting the links between the release-handle and the locking-bar can be shortened, or replaced by fitting shorter links.

(*d*) All bolt and pivot housings should be a true fit to the bolts and pivot-pins, which must not be undersize.

N.B. Bottom-door pivot-pins should be taken out and, if slightly undersize, should be replaced. It is essential for these pins to be frequently greased.

Swing-bar Fastening. The doors which employ this type of fastener can, when strained, be rectified by heating and resetting the two supporting-bars, and replacing any worn bolts. Housings that are worn too large should either be closed, or be drilled out for a larger-diameter bolt.

In some of the early types of 10-ton and 12-ton capacity hopper wagons the door-hinges are found to have insufficient bearing on the locking-bar. The defect in this case is generally due to the design of the vehicle, i.e. constant use and the carrying of minerals ultimately cause the sole-bars to bend outwards at the centre, which results in the bending of the locking-bars and in defective under-door fasteners.

This defect can be remedied by cramping the sole-bars into their correct position, and fitting two cross-bearers inside the hopper, thus tying the sides of the hopper to a set width and containing the load stresses within the hopper. These cross-bearers can be riveted or welded to the centre longitude and the hopper sole-plates, thus preventing distortion of the sole-bars and, most important, of the under-door fasteners.

N.B. It is essential with all-steel hopper wagons to maintain the under-door hinge pivot-pins or -bolts well greased. The under-door control-springs must be maintained in good adjustment, and all release- and locking-mechanism must be well oiled or greased.

CHAPTER IX

WHEELS, AXLE-BOXES, AND BEARINGS

WHEELS and wheel units—The axle-box—R.C.H. Regulations relating to axle-boxes—The wagon-bearing

WHEELS AND WHEEL UNITS

Evolution of Railway Wheel and Track. At a very early period, the coal-mining industry encountered the problem of transportation, which was first effected by the use of panniers on horses' backs. Carts were substituted for these panniers and, in order to facilitate the running of these carts, tramways of flagstones were laid. These carts were gradually enlarged, and ultimately replaced by wagons of four wheels instead of the two previously used.

Similarly, improvements were made to the tracks on which these wagons were to run. In 1630, Beaumont used pieces of planking, laid on wooden sleepers or embedded in the old track, as primitive lines, and later plates were nailed to the upper surfaces of these planks in order to protect the parts subjected to the most friction.

In 1738 the first cast-iron plates were tried at Whitehaven, and the track was called a plateway. This idea spread and plates were soon being used extensively.

The next improvement was the devising of a lip on the plate (Fig. 49A), and in 1776 a cast-iron plateway with lips, and nailed to wooden sleepers, was laid at the Duke of Norfolk's colliery near Sheffield.

There are two known claims to the introduction of the edge-rail and flanged wheel, the first of these being that of Lord Penrhyn's quarries in Carmarthenshire. Here edge-rails were laid on wooden sleepers, and the metals, as they were termed, were of an oval section (Fig. 49B), the wheel-tire being formed to fit the rail. It was subsequently found, however, that the groove was so deepened by wear that it fitted the road too tightly, and in order to obviate this the bearing surface of the rail and the corresponding part of the wheel-tire were made flat (Fig. 49C).

The second claim is that of William Jessop, who, in 1789, constructed a railway at Loughborough, in which he introduced the cast-iron edge-rail with flanged wheel-tires (Fig. 49D). Plain edge-rails were used at other works, the wagons being kept to the track by means of iron guides fastened to the wagons. The guides were made long enough to contact the sides of the rails and thus keep the wagon on the track.

In 1824, when the Stockton and Darlington railway was built, the gauge of 4 ft 8½ in. was used to accommodate the existing wagons, which were also 4 ft 8½ in., and this gauge has been in existence ever since.

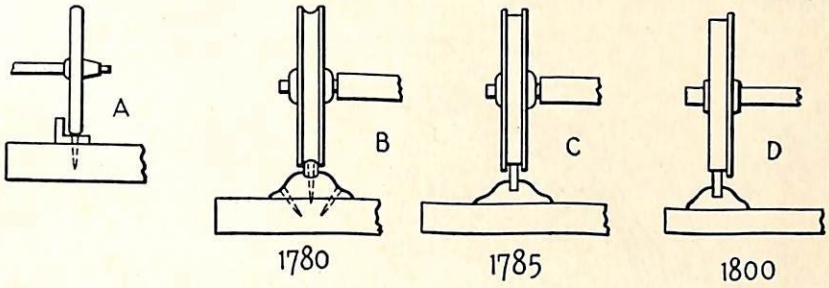


FIG. 49. THE EVOLUTION OF THE RAILWAY WHEEL
A cast-iron tramway nailed to wooden sleepers was laid down in 1776 at the Duke of Norfolk Colliery, near Sheffield.

It is from these beginnings that the modern railway wheel and track have developed.

Manufacture of Solid-disc Centres. The steel for these centres is cast into a circular slab for the required size and weight, and the slabs are then reheated and pressed to the rough form of a

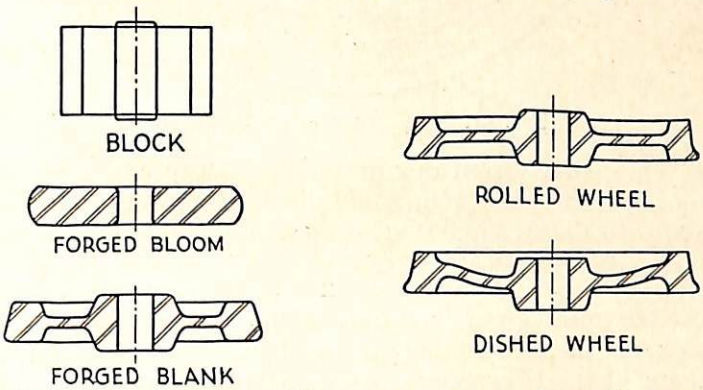


FIG. 50. STAGES IN THE MANUFACTURE OF THE SOLID WHEEL
(By courtesy of Messrs. Taylor Bros. & Co., Ltd.)

wheel in a 2000-ton press. After pressing, the hot wheel-shapes are rolled between horizontal and vertical rollers until the exact size, shape, and section are attained. The wheel is then taken to an 800-ton dishing-press and is given the dish required. The next process in production is to bore through the wheel-boss, which is then ready for forcing on the axle. Lastly, the wheels

are machined to the correct outside dimensions, and are then ready to receive the tires.

The Solid-disc Wheel. This is produced in the same way as the solid-disc centre, the only difference being that the tire and the centre are formed from the same block of steel (Fig. 51).

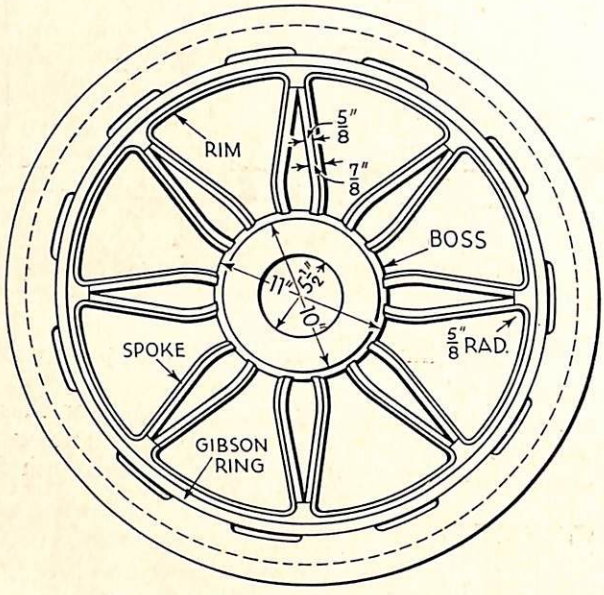


FIG. 51. THE PARTS OF THE WHEEL

The Wheel-tire. From raw material of scrap and pig-iron, tire ingots of open hearth steel are obtained. These ingots are 13, 16, and 18 in. in diameter, 6 ft in length, and have twelve concave sides. The ingots are cut into sections according to the size of the tire required, and these sections are then reheated, flattened, and the centre-hole punched out. From the hammer the blanks are taken to the first rolling-mill, which forms the rough outline and shape of the tire, shown as the outermost portion of Fig. 51. At the next rolling-mill the tires are rolled to within 12 or 15 per cent of the final diameter and are then finally machined to the correct size (Fig. 57).

The Gibson Fastening-ring. The Gibson ring when fastened to the tire is as one unit and, in the rare event of a tire breaking, the fastening-ring will hold the tire securely to the wheel on both sides of the rim. This ring also enables a worn tire to be replaced by cutting off the bevelled lip, removing the Gibson ring, and

heating the tire. This will cause the tire to expand sufficiently to enable it to drop off the wheel-disc or centre.

Fitting the Tire to the Wheel. The heated tire is placed on suitable blocks and the wheel-centre dropped in the tire-centre.

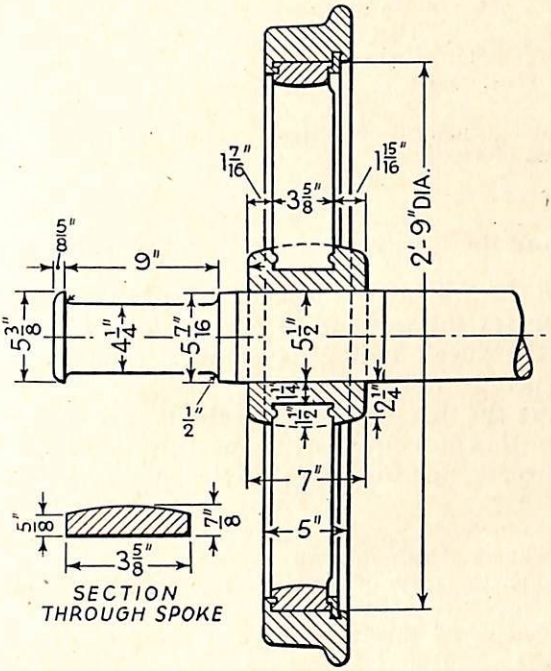


FIG. 52. SECTION THROUGH THE WHEEL

The Gibson ring is then fitted. When the ring is firmly in place and the tires have contracted on to the wheel-centre the lip of the tire is rolled down over the Gibson ring, and the process is complete (Fig. 51).

Measuring Wheel-tires

METHOD I

An accurate method of obtaining the tire thickness is to use the wheel-diameter gauge—

1. Fix the points of the gauge in the centre of the tire and adjust the points to the overall diameter of the wheel-tire surfaces.
2. Remove the gauge and measure the distance between the two points.
3. Deduct from this measurement 2 ft 9 in. (the diameter of the wheel-centres).

4. Halve the remainder: the measurement obtained is the thickness of the wheel-tire.

5. Tires are scrap when the diameter of the wheel is 2 ft $10\frac{7}{8}$ in.

EXAMPLE

Overall diameter of wheel	= 3 ft 1 in.
Deduct wheel centre	= 2 ft 9 in.
Remainder (thickness of 2 tires)	= 4 in.
Thickness of 1 tire	= 2 in.

METHOD II

To measure the thickness of the tires by using calipers—

1. Adjust the calipers to the thickness of the wheel-tire and rim.

2. Having set the calipers to one section of the tire and rim, test round the wheel, finding the smallest thickness and readjusting the calipers to this thickness.

3. Measure the distance between the points of the calipers and deduct from this measurement $1\frac{1}{4}$ in. (the thickness of the rim).

4. The measurement obtained is the thickness of the tire.

EXAMPLE

Thickness of tire and rim	= $3\frac{1}{4}$ in.
Deduct thickness of the rim	= $1\frac{1}{4}$ in.
Remainder = thickness of tire	= 2 in.

N.B. Certain rims are $\frac{3}{4}$ in. thick. These are usually fitted to reconstructed or converted wagons where originally the tires were fitted to the wheels with rivets or set-screws. This type of wheel is scrap at 2 ft $11\frac{1}{2}$ in. diameter and the tires are scrap at $1\frac{1}{4}$ in. thickness.

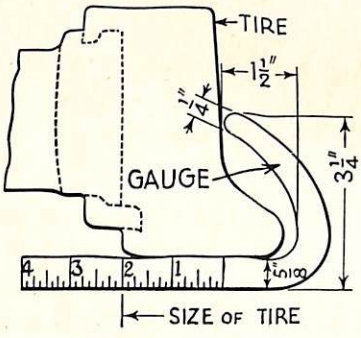


FIG. 53. HOOK GAUGE

METHOD III

The most common method of obtaining tire thickness is by use of a hook-gauge (Fig. 53). The advantage of this tool is that the measurement of the tire is shown on the tool, thus eliminating calculation. The tool is used by pressing it to the inside flange of the tire until the tip of the hook contacts the centre of the wheel-tire, and then reading the measurement, which is shown to

the lip of the tire, which has been rolled down to secure the Gibson ring.

Solid Steel Wheels. The size of the tires is obtained by means of a diameter- or caliper-gauge, and the tires of these wheels must be counted as scrap when the thickness through the throat of the flange is $\frac{13}{16}$ in., or the diameter of the wheel is 2 ft $10\frac{1}{2}$ in. at any point on the tread of the tire. (See Fig. 54.)

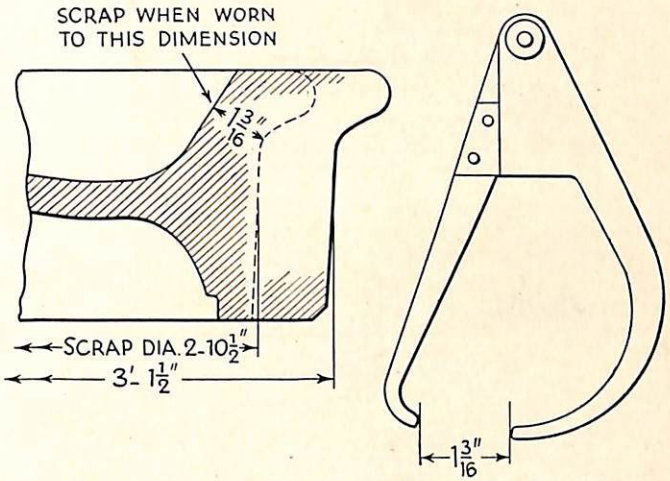


FIG. 54. SOLID-DISC WHEEL-TIRE AND TIRE-GAUGE

Methods of Securing Tires to Wheel-centres

(*a*) *Mansell Fastenings.* Two locking-rings are fitted either side of the wheel-tire, and are shaped to fit in the tire. The locking-rings are secured to the wheel-centre by means of bolts. The thickness of the tire is found by means of the diameter-gauge and must be counted as scrap when the overall diameter is 2 ft $11\frac{1}{2}$ in. or less (Fig. 55).

(*b*) *Jeffrey Fastening.* This tire-fastener is a U-shaped ring, which fits on the tire- and wheel-rim. The thickness of the tire is found by measuring *C* and adding $\frac{3}{4}$ in. It is preferable to use a diameter-gauge. As above, the tires are scrap at 2 ft $11\frac{1}{2}$ in. or less (Fig. 55).

(*c*) *Carlton Fastening.* This method of fastening is similar to that of the Jeffrey fastening, except that it has the addition of a plain ring at the back of the U-shaped ring. Tires secured with the Carlton fastening are scrap when $1\frac{1}{8}$ in. thick (measuring with the diameter-gauge 2 ft $11\frac{1}{4}$ in. (See Fig. 55.)

(*d*) *Gibson Fastener.* This is the most common method of tire-fastening. For details, see Figs. 5–7.

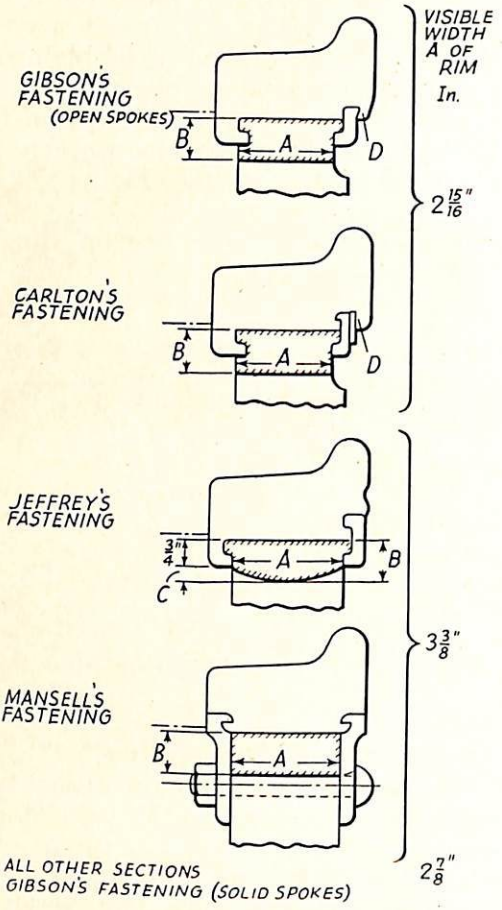


FIG. 55. METHODS OF FASTENING THE TIRE

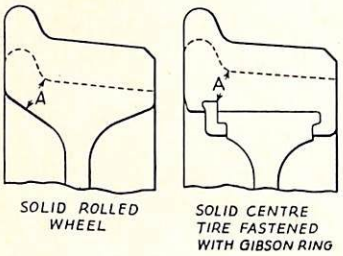


FIG. 56. CRITICAL DIMENSIONS OF THE TIRE

The Wheel Axle (Figs. 52 and 58). The points of interest to repairers of wheel-axles are—

(*a*) The diameter of the middle of the axle.
(*b*) The diameter and condition of the journal.

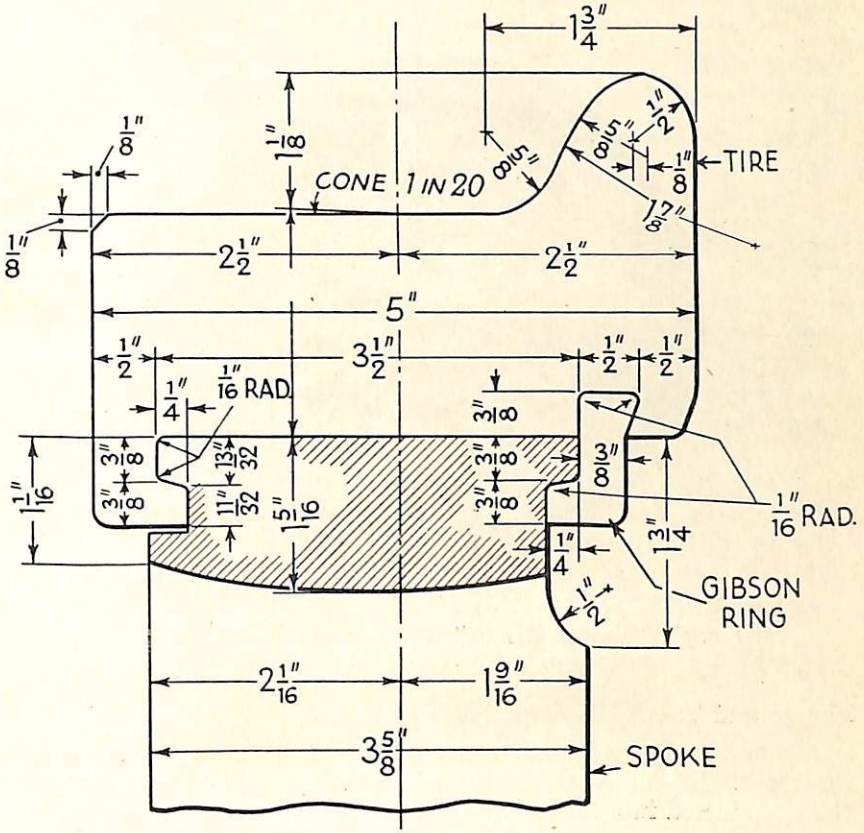


FIG. 57. TIRE SECTION

Bent axles are usually due to—

(*a*) Accident.
(*b*) Excessively hot journals.

The correct method of testing a wheel for a probable bent axle is to put the wheel in a lathe, where defects can easily be seen. To test the axle between the wheels, a road-gauge will give a fairly accurate measurement. The importance must be stressed, however, of the journal being of equal diameter and of sound texture throughout.

N.B. Putting wheels in a lathe is the only test for the true centre of axles and position of wheels.

Wheel-spokes. It is very seldom that spokes are found to be loose in the wheel-boss. The usual defect is corrosion.

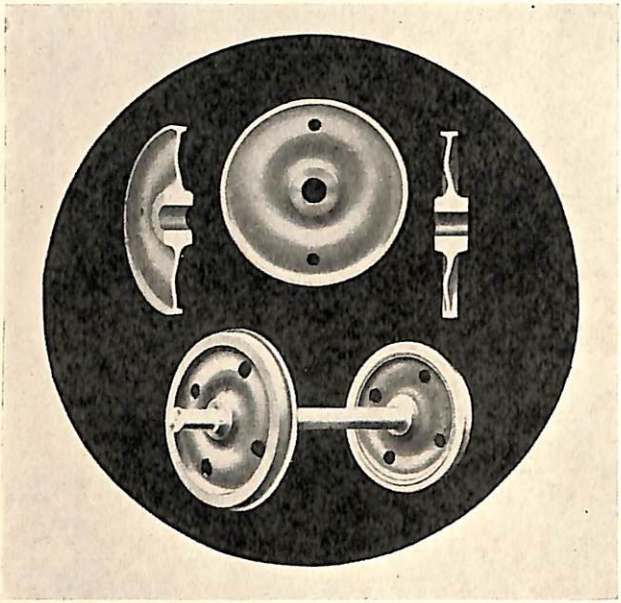


FIG. 58. "EMPIRE BRAND" ROLLED-STEEL DISC WHEELS
(By courtesy of Messrs. Taylor Bros. & Co., Ltd.)

Flange and Tread Diameter of Tires

1. The tire-flange, when worn to $\frac{7}{8}$ in. at a point $\frac{9}{16}$ in. from the top of the flange, is termed a thin flange, and the tire should then be turned in a lath to the profile shown in Fig. 57.

2. Through pressure and friction the tread of the tire wears hollow, and when the depth of the wear is $\frac{3}{16}$ in., the tires must be turned.

3. Only $\frac{1}{16}$ in. is allowed as a variation between the diameters of two wheels on one axle; and on a wagon which has had major repairs, including wheel turning, the wheels must be of equal diameter.

4. It will be seen from Fig. 57 that the tread of tires is coned 1 in 20, thus reducing the circumferential slip when running on a curve of the track.

Renewals of Tires (R.C.H. Regulations). When the tire of an

old wheel is renewed, the renewal tire must be of a thickness corresponding to that of the tire of the other wheel of the pair, provided that it be not less than $1\frac{3}{8}$ in. thick on the tread.

All renewal tires must be secured to the wheels by the standard Gibson fastening, and the spokes and rims of the wheels must be not less than the minimum dimensions laid down.

Wheels with cast-iron bosses when in shops for re-tiring must be subjected to a back-pressure test of 50 tons, preferably in the presence of a railway company's inspector. Provided the test is satisfactory, each end of the axle is to be stamped "50 tons B.P.," with date, followed by the inspector's stamp if the test is witnessed.

Re-axling of Wheels. Old wheels may be replaced by wheels with wrought-iron or steel centres, but wheels with cast-iron bosses will not be accepted for re-axling. If an axle is so far damaged as to require renewal, and the wheel-centres are of wrought iron or steel, the axle must be replaced by a new one, except that for ordinary wagons an axle made since 1887 may be used, provided the journals are not less than 8 in. long by $3\frac{3}{4}$ in. diameter for 8- and 10-ton wagons. The tires in all cases must be not less than $1\frac{3}{8}$ in. in thickness.

Renewal wheels must be pressed on to the axle by a machine which should be fitted with an approved automatic recorder, the record of which must be submitted to the inspector. If, however, the machine is not so fitted, the wheels must be pressed on in the presence of a railway company's inspector.

All renewal wheels must be inspected and stamped on the boss with the Company's Clearing-House stamp and also with the date.

Old 8- and 10-ton wheels having axles with journal centres less than 6 ft 6 in. may be re-tired and used under 8- and 10-ton reconstructed or converted wagons, provided they are in good condition and have rims and spokes of not less than the minimum dimensions.

THE AXLE-BOX

Although numerous designs of axle-boxes have been evolved since cart-wheel bearings, all the designs of axle-boxes have one function and in the main follow the same principles.

There are four purposes which every axle-box must fulfil—

(*a*) Provide a reservoir of lubricant.
(*b*) Provide a seating for the bearing.
(*c*) Provide a seating for the side bearing-spring.
(*d*) Provide a secure method of attachment to the wheels and wagon-frame, in conjunction with the fitting of an axle-guard.

The Grease Axle-box. The axle-box generally in use for grease lubricant is the Ellis design grease axle-box. This box has a movable-drawer grease-chamber, which also is the brass bearing-bed. The advantage of this movable drawer is that it facilitates the withdrawal of the bearing for inspection or attention. If the wagon has bearing trouble when in service, the weight of the load on the bearing is lifted off the bearing, when the drawer can be drawn out and the bearing removed. This is a simple operation suitable to out-station facilities. From one point of view the fit of the bearing on this movable drawer, owing to rough castings and friction, is not such a true alinement of bearing to journal as that attained by the solid type of axle-box.

Dimensional Centre of the Axle-box. The dimensions of the axle-box are determined by the length and diameter of the axle wheel-seat and journal. The dimensional centre is the measurement between the centre of the axle-box bearing-bed and the front lip of the axle-guard groove, plus $\frac{1}{8}$ in., which is the clearance allowance between the face of the axle-guard and the inside lip of the axle-guard groove (Fig. 60).

There are two methods of finding the dimensional centre of an axle-box.

METHOD I (Fig. 59)

Assuming that the axle-box is fixed to the wagon:

(*a*) Measure the distance between the bearing-spring bed-lugs.
(*b*) Mark the centre of this measurement on the side of the axle-box.
(*c*) Measure the distance from this centre-line to the front lip of the axle-guard groove.
(*d*) Add $\frac{1}{8}$ in. for working clearance.

The measurement obtained is the size or dimensional centre of the box.

METHOD II (Fig. 60)

Assuming that the axle-box is free from the wagon:

(*a*) Turn the axle-box bottom upwards. In the centre of the box will be seen the slots where the lugs of the brass bearing fit.
(*b*) Measure the width of the slots on both sides of the box and find the centres.
(*c*) Draw a line across the bed of the axle-box connecting these two centres. This will give the centre of the brass bearing-bed.

(*d*) Place a straight-edged strip of wood or steel, approximately 12 in. long, across the back of the axle-box and level with the bearing-bed.

(*e*) Measure the distance from the centre-line marked on the axle-box bearing-bed to the inside edge of the straight-edged strip.

(*f*) Note the measurement obtained and keep the straight-edged strip in the same position.

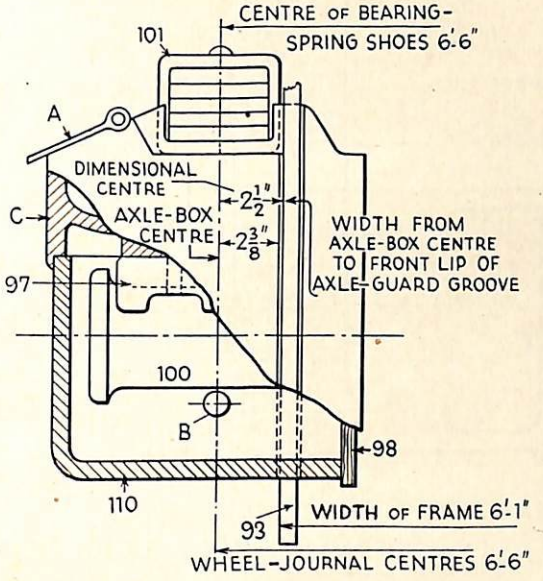


FIG. 59. ELLIS GREASE AXLE-BOX

93. Axle-guard.
97. Journal-bearing.
98. Axle-box dust-shield.
100. Wheel-journal.
101. Side bearing-spring.
110. Axle-box.
A. Axle-box lid.
B. Axle-box under-cap bolt.
C. Axle-box grease-container.

(*g*) Place the rule at the side of the axle-box, fixing the measurement obtained from the centre-line of the bearing-bed to the inside edge of the strip.

(*h*) Read the measurement from the end of the rule to the nearest side of the axle-guard groove and add $\frac{1}{8}$ in.

This measurement will give the dimensional size of the axle-box. (See Fig. 60.)

Design of an Axle-box. On either side of the inside of the axle-box will be seen two pillars, which serve to strengthen the sides, and also form part of the construction for securing the brass bearing in position and preventing the journal from rolling off

the bearing when in motion. Round the back of the axle-box will be found a groove for the provision of a dust-shield, which prevents dirt collecting on the journal. In conjunction with this dust-shield an under-cap is fitted by means of a bolt through the axle-box under the wheel-journal. This bolt has the additional

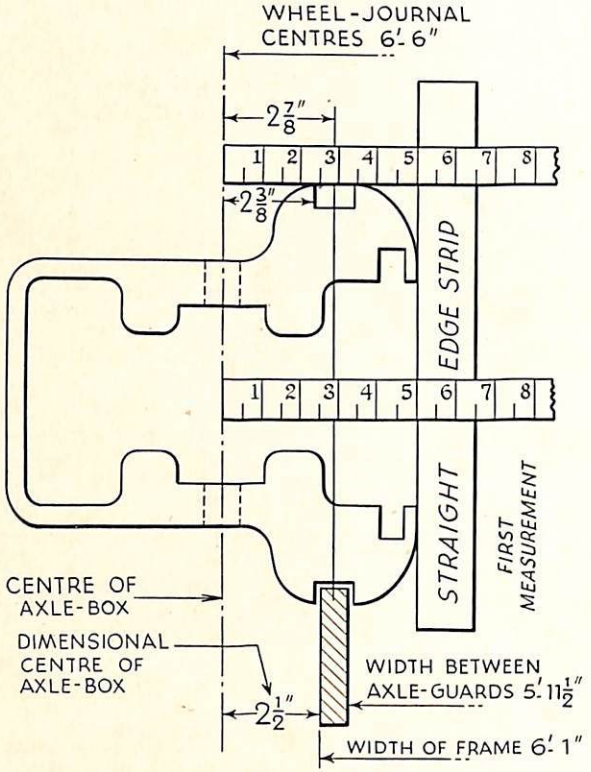


FIG. 60. METHOD OF OBTAINING DIMENSIONAL CENTRE OF AXLE-BOX

function of keeping the wheel in position and preventing the displacement of the bearing. (See Fig. 61.)

Testing the Bed of the Grease Axle-box. The most important part of an axle-box is the grease-drawer, which not only must be a good fit, but must also be tested for bearing-bed squareness and levelness, i.e. the drawer should be at right-angles to the axle-guard grooves. Without a template, complete accuracy in the testing of the bearing-bed is not possible, but a rough guide is to hold a flat board on the back of the axle-box and use this as a base for the square to be used. Alternatively, a piece of straight-edged

wood can be placed across the bottom of the axle-box to measure the distance between the front and the back of the bearing-bed. If the axle-box drawer should tip either way, the top edges of the drawer must be filed until the bearing-bed of the axle-box

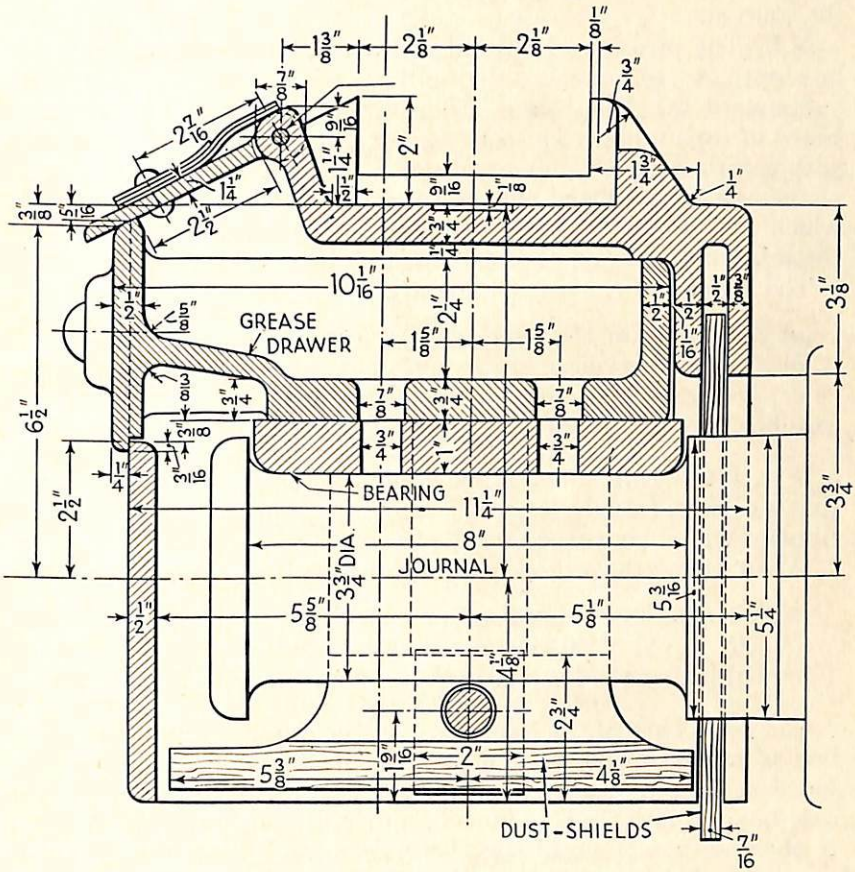


FIG. 61. GREASE AXLE-BOX

drawer is square and level. Care must be taken that all dirt and sand are cleared from the inside of the axle-box, and especially from the axle-box drawer. With any type of axle-box the bearing-bed must be tested; and if this is found to be so much out of alinement that it is difficult to rectify, it is advisable not to fit the axle-box rather than to attempt to alleviate a hot axle-bearing.

The Oil Axle-box. The function of oil axle-boxes is the same as that of grease axle-boxes, the only difference being in the

method of lubrication. In grease axle-boxes the lubricant is fed to the top of the journal, whereas in oil axle-boxes it is fed to the bottom of the journal by means of special oil-pads constructed with coil or laminated springs, ensuring constant contact with the journal.

N.B. The pressure of any oil-pad against the journal may not be less than 5 lb nor more than 6 lb.

Standard Oil Axle-boxes. The standard oil axle-box is composed of top and bottom sections, the jointing of which is packed with a cork liner, which constitutes a dust-proof joint. The back of the axle-box is fitted with a dust-shield with a leather washer, which fits round the wheel-seat of the axle, thus ensuring that the interior of the axle-box is kept free from all dirt.

The interior of the axle-box contains—

(*a*) A seating for the bearing (which must be perfectly level).
(*b*) An oil reservoir.
(*c*) A housing for the oil-pad in the bottom section of the axle-box.

It is interesting to note that this axle-box is so constructed that no loss of oil takes place when the wagon is unloaded by tipper devices, i.e. turned upside down.

When fitting the axle-box, care must be taken to see that—

(*a*) The bearing-seat is level and properly cleaned.
(*b*) The top and bottom sections fit correctly.
(*c*) Oil-pads have been soaked in oil for the previous 48 hours.

The Solid Type of Oil Axle-box. As the name implies, this axle-box is cast in one unit, and a movable liner or drawer is provided to facilitate the fitting of the bearing. The front of the axle-box is movable bolt-hinged, and is the only means of entry to the axle-box when fitting the bearing and oil-pads, and when re-oiling. This type of axle-box is not suitable for a wagon unloading with tipping devices, but it has the advantage of good facilities for the inspection of the bearings and oil-pads when the wagon is in service.

The points requiring careful attention are—

(*a*) The axle-box liner must be a square fit and the surface of the bearing-bed must be level.
(*b*) The dust-shield must have good contact with the journal-seat.
(*c*) The interior must be cleaned.

(*d*) Testing the bearing bed, with the following points to be observed—

1. Assume that the wagon is lifted at one end, and the wheels are free. (The journal must be of equal diameter in its length.)
2. Place the wheels in a true horizontal position with the aid of a spirit-level placed on the journal.
3. Place a new bearing or one of equal thickness in the axle-box, and then put the axle-box in position on the wheel-axle.
4. Attach a plumb line weighted to the wagon and so positioned that the line is close to the axle-guard grooves.
5. Measure from the line to the edge of the axle-guard groove at the top of the axle-box, note the measurement, and compare this dimension with the axle-guard groove at the bottom of the axle-box.

If the axle-guard groove lip is equal distance from the plumb line, then the bearing seating is in true position.

R.C.H. REGULATIONS RELATING TO AXLE-BOXES

War-emergency Revision. Axle-boxes with lugs at the back of the spring-seat, broken to such an extent as to fall within the limits indicated on Drawing R.C.H. No. 920, need not be renewed.

Clause 38: Axle-boxes may be used again, provided they are in good condition and of approved design; the bearings, where possible, to be deep-lugged and to Drawings Nos. 95 or 213. Axle-boxes with deep-lugged bearings must be fitted when boxes which will not accommodate deep-lugged bearings require replacement.

In the case of 8- and 10-ton ordinary wagons, grease chambers must have a capacity of not less than 90 cub in. Dust-shields and a bolt through the box beneath the journal must be fitted.

Where grease axle-boxes are fitted to tank wagons and to 12-ton ordinary wagons built without end-doors to the 1907 Specification, they must be replaced by oil-boxes of the standard design. This last paragraph applies to rebuilding only.

R.C.H. Regulations of Minimum Dimensions as Applied to Axle-boxes, 1937. Grease axle-boxes on 8-, 10-, and 12-ton wagons may at owner's option be replaced by oil-boxes in accordance with Drawings Nos. 189 and 1031; but when grease axle-boxes of 12-ton wagons, built after 31 December, 1920, require replacement at works, oil axle-boxes must be fitted.

THE WAGON-BEARING

The wagon-bearing is one of the most important components of the wagon, and it is essential that it should be made of the correct mixture of metals, as defined by R.C.H. Regulations.

Bearings that conform to the specification are easy to fit to the journal, and in the initial stages of service are very quickly run in to a load-carrying fit on the journal.

Bearings made with a preponderance of scrap metal are generally of a very hard nature, owing to the foreign matter contained in them, and are liable to become hot.

The composition of the grease-metal bearing stipulated by R.C.H. Regulations is—

Pure copper	88 per cent
Tin	10 per cent
Zinc	2 per cent

Minimum Dimensions of Grease Bearings. R.C.H. Regulations affecting the minimum dimensions at which the bearing must be replaced are—

	Thickness	*Length*
8- and 10-ton ordinary wagons, grease bearings	$\frac{1}{2}$ in.	Not more than $\frac{1}{2}$ in. less than the length of journal.
12- and 15-ton ordinary wagons . .	$\frac{5}{8}$ in.	Not more than $\frac{1}{2}$ in. less than the length of journal.

Fitting of Bearing to Axle-box. The following points should be given careful attention—

(*a*) Test the fit of the bearing in the axle-box.

(*b*) The bearing must be fitted accurately to the bearing-bed of the axle-box.

(*c*) The grease feed-holes must be correctly alined.

Inspection of the Journal. Examine the surface of the journal. If it is pitted with small holes or cracks are visible in the texture of the steel or iron journal, it can be resurfaced as follows—

(*a*) If the defects are slight, the journal can be resurfaced by scouring by hand. The tool used for this purpose is shown in Fig. 62.

(*b*) If the defects are more serious, machine-turn the journal.

The journal must be the same diameter throughout its length. If there is any variation, it is advisable to machine-turn the journal. The collar-end of the journal should be correct in profile, otherwise the useful life of the bearings is considerably shortened.

Fitting of the Bearing to the Journal

1. Using thin paint, make a line of paint about $\frac{1}{2}$ in. wide along the length of the journal.

2. Place the bearing carefully on the journal. With hand pressure, place the thumbs on top of the bearing and, with fingers gripping the bottom of the journal, move or rub the bearing on the journal with equal pressure for about ½ in. right and left of the longitudinal centre of the journal.

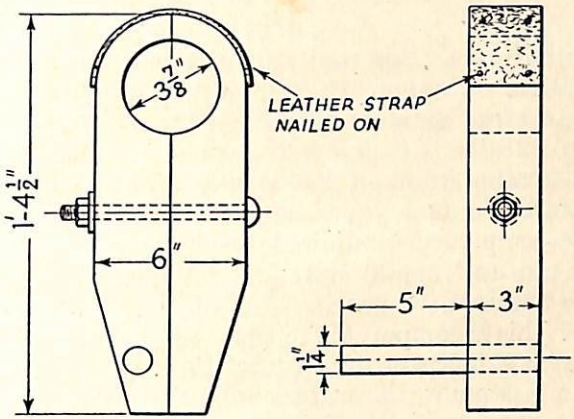


FIG. 62. JOURNAL HAND-SCOURING CLAMP

3. Slide the bearing off the journal. The places on the bearing where the paint has rubbed off the journal on to the bearing must be filed or scraped.

4. This process must be repeated until a continuous line of paint shows along the full length of the journal face of the bearing, about 1½ in. wide.

When this has been achieved, the bearing can be said to be fitted to the journal.

It must be recognized, however, that unless the bearing, journal, and axle-box are correct, a true bearing fit on the journal cannot be obtained, and thus any faults which are not rectified will cause a faulty fit of bearing to journal when the wagon is under load. In these circumstances, a hot axle-box can develop.

Lubricant. If two pieces of wood (or any other substance) are rubbed together vigorously, heat is generated (friction heat); but if the two pieces of wood are smeared with some oily substance they can be rubbed against each other for an indefinite period without producing friction heat, providing a very important condition is maintained—"the friction heat" caused by the speed of rubbing is related to the "limitations" of the lubricant used.

The above simple example is applicable to wagon grease, the limitations of which obviously lie in its composition. Grease used for the lubrication of wagon bearings consists of the following matter—

Mineral oil	(not less than)	10 per cent
Wood fat and soda soap . .	(not more than)	40 per cent
Water		50 per cent

From this it can be seen that the main constituent of wagon grease is water. A wagon when in service is without any protection against the extremes of climatic conditions. The effect of low temperatures is to freeze the water content of the grease (imposing a greater strain on the locomotive) and in high temperatures the water content vaporizes. The important factor, however, is the temperature required to change the grease from a semi-solid state to a liquid state. To achieve this, friction heat is necessary between the bearing and journal to a temperature of 100–120° F. (this is comparable to that of pleasantly warm water). To boil water a temperature of 212° F. is required. If friction heat rose to this point, the water content would evaporate. This means that the working efficiency of this grease is between temperatures of 120–200° F.

Hot Bearings. Hot bearings, or hot boxes as they are termed, are mostly grease-lubricated bearings, but although the limitations of grease in relation to speed have been outlined, there are other circumstances that cause hot bearings. Apart from the faults noted previously in connexion with the precautions to be taken when fitting the bearing to the axle-box and journal, other known causes are—

1. Load unevenly distributed.
2. Weak side-springs.
3. Wide wagon-frame (width between the sole-bars not in relation to the centres of the axle-boxes and wheels).
4. Axle-guards not of equal centres, or in a square position longitudinally or diagonally.
5. Unequal wheel-base centres.
6. Wheels of unequal diameters.
7. Dirty axle-boxes and grease- or oil-pads.
8. Broken dust-shields.
9. Shortage of lubricant.
10. A sharp run on new bearings.

Generally, when new bearings run hot, the wagon is part of a fast-moving train. Obviously the new bearing not previously

"run in" (as it usually is) to a load-carrying fit on the journal generates friction heat very quickly. This affects the grease which, owing to the increasing heat, loses through evaporation an increasing quantity of its main constituent, water. The hot grease also loses its ability to stick to the journal and is thrown all over the inside of the axle-box. This shortage of lubricant in the following half of the bearing aggravates the increasingly hot condition of the bearing and, if it is not allowed to cool, a destructively hot axle-box materializes. As a result, the axle-box is lost and the continuity of railway traffic is interrupted.

If, as sometimes happens, the wagon is run on short, slow journeys until the bearings are run in, they undergo on several occasions warm friction heat and, given a plentiful supply of grease, accommodate themselves to the weight of wagon and load.

Oil Bearings. The difference between oil bearings and grease bearings is that the oil bearing has a metal-lined surface of white metal, which is of a softer nature than brass, and is easily fitted to the journal by scraping. The white metal is fixed to the brass bearing as follows—

1. The brass should be thoroughly cleaned and, after being heated, should be tinned on the face with soft solder (one part tin and two parts lead), or in a bath of tin at a temperature of about 635° F. The parts of the brass not to be tinned should be coated with limewash, the tin in either case to be applied with a flux of chloride (spirits of salts reduced by zinc).

2. The white metal, at a temperature of about 680–700° F., should be applied to the brass in a suitable mould, the mould to be hand-hot about 120° F. and the temperature of the brass about 445° F. The molten metal is filled into the top of the mould to prevent a hollow bearing.

The Fitting of Bearings. Take the same precautions as outlined for grease bearings. The width of the bearing contact on the journal must be a minimum of 1½ in.; if the bearing contact is made less than stated, the white metal lining of the bearing would spread when subjected to load stresses.

Do not use a file to fit the bearing to the journal: white metal must be shaped with a scraper.

The requirements to bear in mind are equal thickness of bearing, a dead fit to the axle-box bearing-seat, and a dead fit to the wheel journal lengthwise.

Oil Pads. The oil pad is an important means by which lubricant is conveyed to the bearing. Insufficient attention to the fit and working efficiency of this pad will result in hot bearing.

It is essential to check the bearing fit of pad to the journal, as well as to the axle-box.

See that the elasticity of spring has free movement.

Any bearing which has not a sufficient supply of lubricant for the work imposed, generates heat. It is no exaggeration to say that a large proportion of mechanical breakdowns is due to faulty lubrication. Many a wagon has been crippled through lack of this simple maintenance, involving so little an expenditure.

Lubricating Oil. The oil should be either a pure mineral lubricating oil, or a mixture of this with a non-drying animal or vegetable oil. It must be free from suspended matter, water, acid, or alkali, resin, resin oil, and soap or other artificial thickening agents.

Specific gravity at 60° F., not to exceed 0·940.
Flashing-point (close test), not below 330° F.
Efflux time from Redwood's visiometer:
at 1400° F., 110 to 140 seconds;
at 700° F., not more than ten times that of the same oil at 140° F.
Cold test, to flow at 20° F.

The oil must be a pale red colour by transmitted light.

As will be seen from what is given above, oil flows below freezing-point and can withstand heat above boiling-point.

REMARKS—

The oil bearing is trouble-free if common-sense maintenance is effected. The following points should be watched—

(*a*) A plentiful supply of oil is required.

(*b*) Only oil-pads that are clean and soaked in clean oil shall be used.

(*c*) Metal linings of bearings must be in good condition, and a good fit to the wheel-journal and axle-box.

(*d*) Dust-shields must be in good condition.

(*e*) All other requirements regarding the accuracy of wagon-frame, as well as iron and steel parts, must conform to the R.C.H. Specification to which the wagon was built.

(*f*) New bearings should be run in to a load-carrying fit, with light loads on slow trains and short journeys.

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